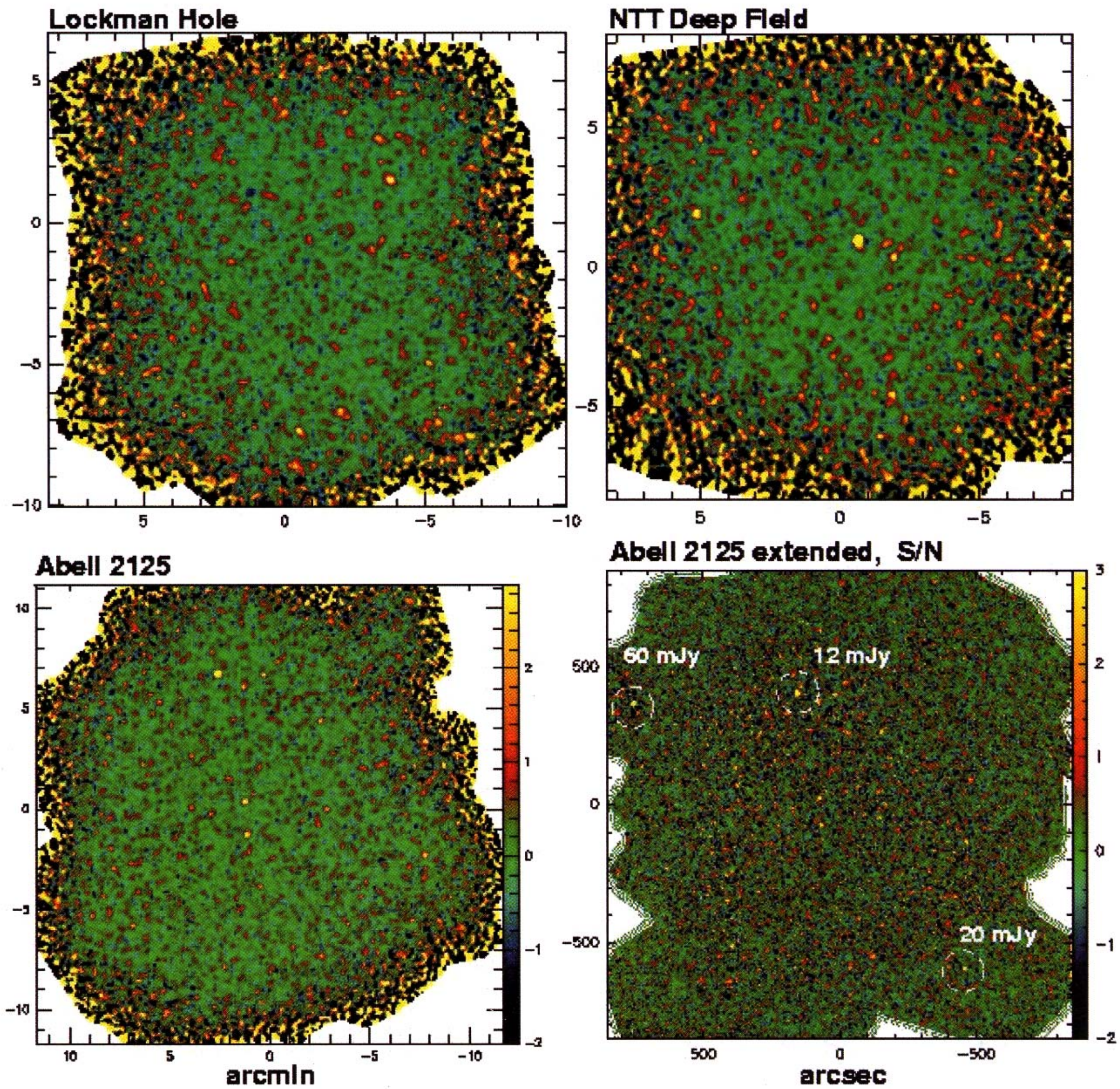
IRAM 2002



ANNUAL REPORT

Front Cover: *Upper row and lower left:* The three MAMBO deep fields, observed with the IRAM 30-telescope. Noise levels are typically 0.5 to 0.7 mJy in the field centers, rising towards the edges due to low exposure. Dimensions are arcmin, flux levels mJy. *Lower right:* Extending the deep MAMBO survey with shallow imaging in the flanking fields of Abell 2125 and the Lockman Hole, a group of scientists from the MPIfR detected three extremely bright sources in the Abell 2125 field, which is displayed here as a signal/noise map. These objects are clearly identified with low redshift (about 0.3, 0.29, 1.38), radio-loud and X-ray-bright QSOs. They appear to belong to a population different from the fainter MAMBO and SCUBA background sources which are radio- and X-ray-quiet, higher-redshift, optically obscured starbursts. (Copyright: Bertoldi, Carilli, Menten/ MPIfR, Bonn).

ANNUAL **REPORT**

2002

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1. INTRODUCTION

The year 2002 has been a year of major scientific achievements but also a year of significant changes and of important decisions that will bear on future developments.

On the scientific side some spectacular observations have been carried out, both with the 30m-telescope and with the 6-element Plateau de Bure Interferometer. From the many highlights which are described in Chapter 2 of this Report, the detection of CO molecules and dust in very high redshift sources must be mentioned, as well as the first successful detection of VLBI fringes at 2mm in a transatlantic VLBI experiment with an unprecedented angular resolution. During the fall of 2002, the PdB Interferometer participated for the first time as a phased array in such VLBI experiments, giving a boost to the sensitivity of such experiments which can now be carried out with much better signal to noise ratios.

hi continuation of the efforts to re-establish a safe, reliable and efficient operation of the Plateau de Bure observatory, the change of the management structure which led in 2001 to the creation of the "Cellule Bure" in Grenoble, was completed with the hiring of a new Station Manager, Bertrand Gautier, who started his work in April. Chapter 4 contains a report of the activities which have been started under the new leadership as well as a description of some of the future plans.

Another major change in the management team occurred in April 2002 with the arrival of Gilbert Klein as the new Head of Administration after the departure of Christelle Mesureur at the end of 2002.

On the technical side, important progress has been made both in the laboratories and at the observatories. This is reported in the Chapters 3, 4, and 5. The laboratories faced the special challenge to advance at the same time the IRAM development projects for the 30m-telescope (upgrade of the HERA receiver to 18 channels, new backends etc.) and the Plateau de Bure Interferometer (water vapour radiometers to allow in the future phase corrections, preparation of the next generation receivers, change of the IF signal transport system to optical fibers etc.), and the development of critical components for the ALMA project (e.g. the Band 7 receiver). A similar challenge occurred for the computer and software groups which are equally involved both in IRAM's own development projects and work for ALMA. With ALMA entering into Phase 2 of the project, we will have to consolidate this situation by strengthening the groups that will produce hard- and software for ALMA in the future.

Because of the key role of software for the efficient calibration, reduction and interpretation of data obtained at the IRAM observatories, and with ALMA as of 2007, IRAM has created a new group for scientific software development. This group is headed by Frederic Gueth and still in the build-up phase. It will hopefully become the nucleus for a collaborative effort, together with several other European institutes, to provide regional support for the scientific user communities.

An important milestone has been reached in the fall of 2002 for the future access to the Plateau de Bure Observatory. On the basis of the technical studies and administrative/legal inquiries that the CNRS-INSU has initiated, and after a series of discussions with the local authorities, it was finally decided that the CNRS will create the horizontal tunnel and a vertical elevator of about 200m height which together will allow to overcome the steep mountain ridge that makes the access to the plateau so difficult. In parallel, the local authorities are preparing a new transport system in the lower part of the mountain slope, between the existing ski station at Superdevoluy and the skiing area near Sommarel. In this part IRAM is currently using a piste with a 4-wheel drive car in summer, and a ratrack in winter. Once the new cable car system is ready, this will no longer be necessary.

The fact that major new investments will soon be made for the Plateau de Bure Observatory by the CNRS (new access) and all three partners together (new receivers, longer baselines etc.), as well as IRAM's longer-term commitments to the ALMA project, have triggered reflections about IRAM's future mandate. The Executive Council established a Council Subcommittee in October 2002 which has since met once. Its work will probably culminate in a major review activity in the 2005-2007 timeframe in order to discuss IRAM's role as of 2010.

We are fortunate to be able to keep investing into progressive improvements of the scientific capabilities of our instruments and into new techniques that allow new technological developments and breakthroughs that will later benefit the observatories. In this context, we gratefully acknowledge the support that the IRAM funding organisations, the CNRS, the MPG, and the IGN are giving us, despite their own very substantial budgetary problems. While IRAM has been actively involved in preparing proposals to the European Union for funding under the new FP6 program, our core activities rely on the long-term commitments of the IRAM partner organisations.

2. HIGHLIGHTS OF RESEARCH WITH THE IRAM TELESCOPES IN 2002

2.1 SUMMARY

Among projects at the IRAM telescopes done or published in 2002, a few highlights were :

- **High-redshift CO:** New studies of CO and dust emission from high-redshift quasars and starburst galaxies.
- **Starbursts:** Widespread HCO emission in the nuclear starburst of M82.
- **Nearby Galaxies:** A fully-sampled survey of molecular gas in M31 at 23 arcsec resolution.
- **Protostars:** The disk and jet of the high-mass protostar IRAS 20126+4124.
- **Molecules:** Deuterated molecules and ions toward low-mass protostars.
- **Circumstellar Envelopes:** Map of CO in the bipolar envelope of IRAS 17436+5003.
- **Supernova Remnants:** Bolometer map of the Crab Nebula supernova remnant at 1.3 mm.
- **Solar system:** New millimeter detections of Edgeworth-Kuiper Belt Objects.

2.2 EXTRAGALACTIC RESEARCH

New studies of CO from high-redshift quasars and starburst galaxies.

In the past year, the interferometer has been used for studies of CO line emission from the following high-z sources, most of which are known to be gravitationally lensed. It is intriguing that to within a factor of ~2, these sources have the same 3mm CO flux, which suggests their CO luminosities are amplified by gravitational lensing by similar factors of up to - 10 to 20.

The quasar PSS 2322+1944 at *z*=4.1199 has a CO(4-3) flux of 4 Jy km/s and a linewidth of 375 km/s (Cox et al. 2002, A&A, 387, 406; see color maps in last year's IRAM annual report). This source appears as a gravitationally-lensed Einstein ring in VLA maps of CO(2-1) (Carilli et al. 2003, Science, in press). The dust and gas mass are thus lower than previously estimated, consistent with gas in a sub-kpc scale circumnuclear molecular ring.

The quasar MG 0751+2716 at z=3.200 has a CO(4-3) flux of 6 Jy km/s and a width of 390 km/s. The CO and dust magnification is estimated by the authors to be a factor of 17, so the true mass of molecular gas is a few times 10^9 Msun, again characteristic of a circumnuclear molecular ring (Barvainis, Alloin, & Bremer, 2002, A&A, 385, 399).

The starburst galaxy SMMJ14011 at z=2.5652 : Contrary to an earlier result suggesting a huge galaxy-size molecular disk, the IRAM interferometer data **(Fig.** 2.1) show a compact source in CO(3-2) and CO(7-6). The CO(3-2) flux is 3 Jy km/s, and the ratio of observed-to-intrinsic brightness temperatures of these lines implies a lens magnification factor of 25, possibly by a combination of lensing by the foreground cluster Abell 1835 at z = 0.25 and lensing by another galaxy on the line of sight. The true gas mass and dynamical mass within the CO-emitting region would then be several times 10^9 Msun, again typical of a circumnuclear starburst region (Downes & Solomon, 2003, ApJ, 582, 37).

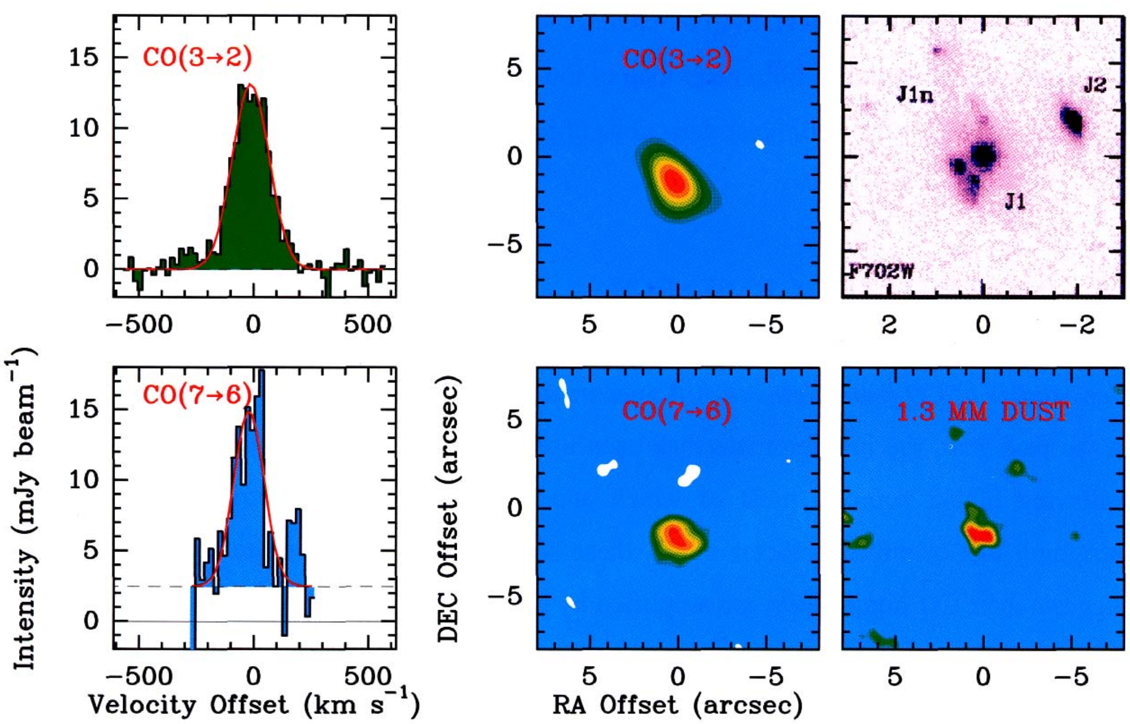

Fig. 2.1: CO in the starburst galaxy SMMJ14011 at z=2.5652. *Upper left:* Interferometer CO(3-2) spectrum with 20 km/s channels, beam *1"* x *6". Lower left:* CO(7-6) spectrum above the 2.5 mJy dust continuum, 20 km/s channels, beam 2" x *2". Upper middle:* Interferometer map of CO(3-2) integrated over 260 km/s, beam 3" x 2", integrated flux 2.8 Jy km/s. *Lower middle:* Map of CO(7-6), beam 2" x 2", integrated flux 3.2 Jy km/s. *Upper right:* Hubble Space Telescope F702W image, from Ivison et al. (2001), of the central 6" x 6" of the CO maps. *Lower right:* Interferometer map of the dust emission at 225 GHz, beam *2"* x 2", integrated flux 2.5 mJy.

The quasar SMMJ02399 at *z*=2.808 : The optical through X-ray properties of this source resemble those of local type 2 AGNs and broad absorption line QSOs (e.g. Vernet and Cimatti 2001, A&A, 380, 409). The optical image shows two spots ("LI and L2"), separated by 3", with each spot showing an emission line spectrum with linewidths of -2000 km/s; the He II and Lya fluxes of L2 are half those of LI, so the two spots may be images of the same quasar, gravitationally lensed by the foreground cluster A370 at z=0.37 (Ivison et al. 1998, MNRAS, 298, 583. See, however, see also de Mello et al. 2002, ApSS, 281, 549 who find evidence for a line-of-sight galaxy at z=0.94). The source has been observed with the IRAM interferometer. The CO(3-2) maps show two components 2.5" apart, with the CO peaking near the eastern optical source L2. The authors (Genzel et al. 2003, ApJ, 584, 633) interpret the CO as coming from a 16-kpc disk, and hence a very massive galaxy (> 3×10^{11} Msun in a diameter of 16 kpc) that does not easily fit cold dark matter scenarios of galaxy formation.

The radio galaxy B3 J2330+3927 at *z*=3.094 : The IRAM interferometer data yield a CO(4-3) flux of 1 Jy km/s, one of the faintest high-z CO detections to date. In the Very Large Array map of the radio continuum at 8 GHz, this source consists of three barely resolved (<0.3") spots that would normally be interpreted as a double-lobed radio galaxy, with two lobes 1.9" apart, on opposite sides of an AGN core source. Extended Lyman-alpha emission is detected at the "lobes," as in other radio galaxies. The position of the CO emission is surprising because it comes from the northern "lobe," suggesting that the real galaxy is there, not at the central source of the radio continuum triplet (de Breuck et al. 2003, A&A, 401, 911).

Studies of mm-emission from dust in high-redshift quasars.

During the past three winters, observations at 1.2 mm with the MPIfR MAMBO bolometer arrays at the 30 m telescope have been made of a large sample of high-redshift quasars. Searches for mm emission were made towards 150 quasars at $z \sim 2$ to 6, with more than 40 detections. Most of the QSOs are radio quiet, with cm- to mm-flux ratios similar to those of nearby starburst galaxies. There are no correlations between redshift and far-IR/submm luminosity or between optical and far-IR/submm luminosity (Omont et al. 2003, A&A, 398, 857). Thermal mm dust emission has been detected from a radio-quiet QSO at z = 5.5, at a level of 0.9 mJy, one of the weakest of the high-z dust sources detected to date **(Fig.** 2.2). The farthest quasar detected at 1.2 mm to date is the object SDSS Jl 148 at z = 6.4 (Bertoldi et al. 2003, A&A, in press).

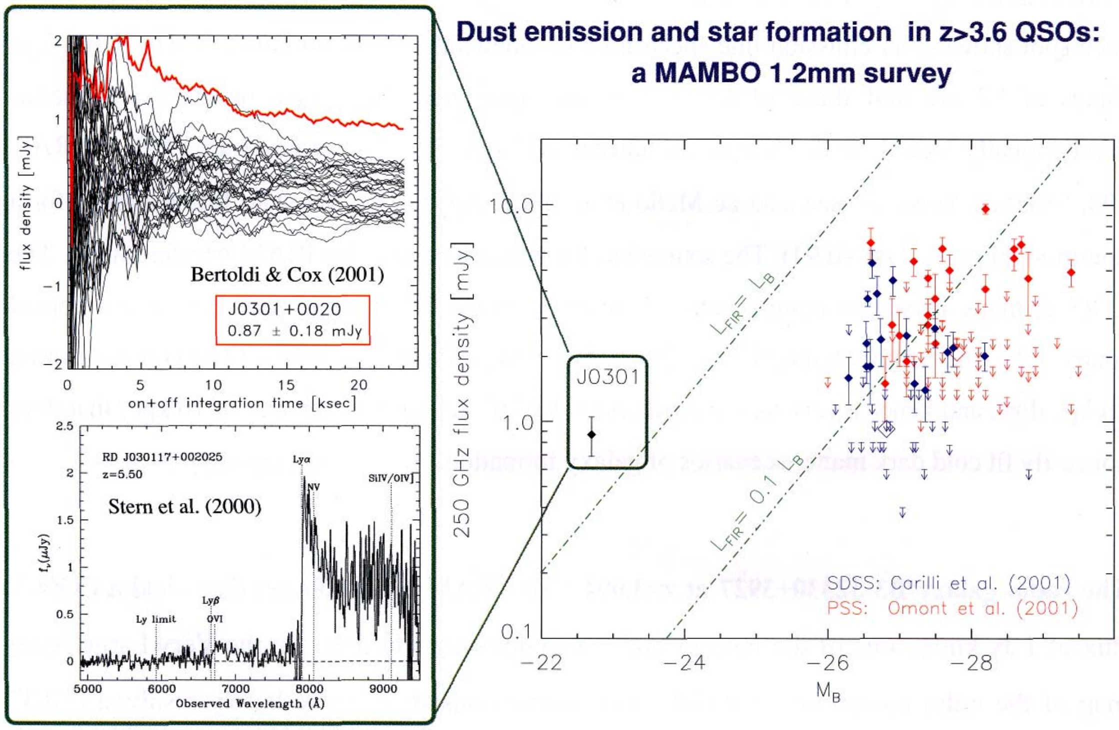

Fig. 2.2: MAMBO detection of dust in a low-luminosity quasar at z=5.5. *(Upper left:)* Mean flux versus integration time for one, central, on-source bolometer (thick red curve) and 32 off-source bolometers (thin black curves). The central bolometer detected the quasar RD J030117+002025, whose optical spectrum has a sharp cutoff at wavelengths shorter than redshifted Lyman alpha *(lower left). (Right):* Location of the z=5.5 quasar J0301 in a plot of 250 GHz flux density measured at the 30m telescope, versus absolute magnitude measured in the optical B band. Most of the quasars in the search samples are among the optically brightest QSOs. The mm-brightest quasar on the plot (near 10 mJy) is PSS 2322+1944 at z=4.1, in which CO was detected in 2001 with the IRAM interferometer. (Diagrams from Bertoldi & Cox, 2002, A&A, 384, LI 1).

Widespread HCO emission in the nuclear starburst of M82.

The IRAM interferometer has been used to map the formyl radical HCO in its (F=2-l) emission in the nuclear starburst of the nearby dwarf galaxy M82. This is the first map of this radical in any galaxy other than our own **(Fig. 2.3).** The HCO emission comes from the well-known circumnuclear molecular ring of diameter 650 pc, and appears to be concentrated toward its outer edge. Up to now, the HCO radical has been thought to be associated with photon-dominated regions (PDRs) at the interface between ionized and molecular gas. Contrary to what might be expected from such a PDR interpretation however, the HCO in M82 is not correlated with the well-known H II region complexes in the circumnuclear ring, which are strong sources of UV photons. The HCO emission is also not correlated with $H^{13}CO^{+}$, an ion long regarded as a classic PDR tracer. In the outer edges of the ring, the HCO abundance is surprisingly high, ~4 x 10^{-10} , relative to molecular hydrogen. These new observations provide a strong stimulus to revise existing PDR models (Garcia-Burillo et al. 2002, ApJ, 575, L55).

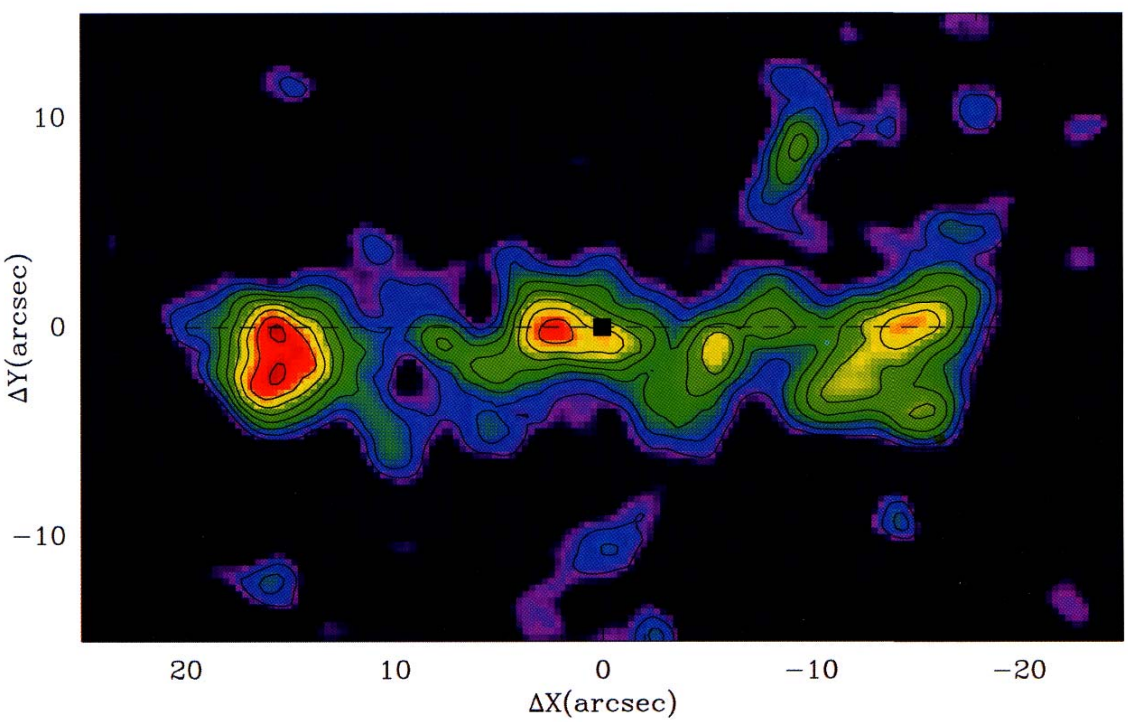

Fig. 2.3: HCO emission in the circumnuclear molecular ring of M82. Interferometer map of HCO (F=2-l) emission at 86.67 GHz in the nuclear starburst ring of M82. Coordinates are offsets along the major and minor axes of the nuclear ring, relative to the 2-micron peak (black square). Contours start at 3-sigma (0.144 Jy km/s) and reach a peak value of 0.35 Jy km/s in a 5.8 arcsec beam. At the distance of M82 (3.9 Mpc), 1 arcsec equals 20 pc.

A fully-sampled survey of molecular gas in M31 at 23 arcsec resolution.

The 30 m telescope has been used to survey the CO(1-0) line in the Andromeda galaxy M31 over an area of about 1 square degree with a beam of 23 arcsec. The survey was made in the on-the-fly mode, with a grid sampling of 4 arcsec. The map **(Fig.** 2.4) shows the CO emission is mainly in narrow spiral-arm segments that break up into thinner filaments.

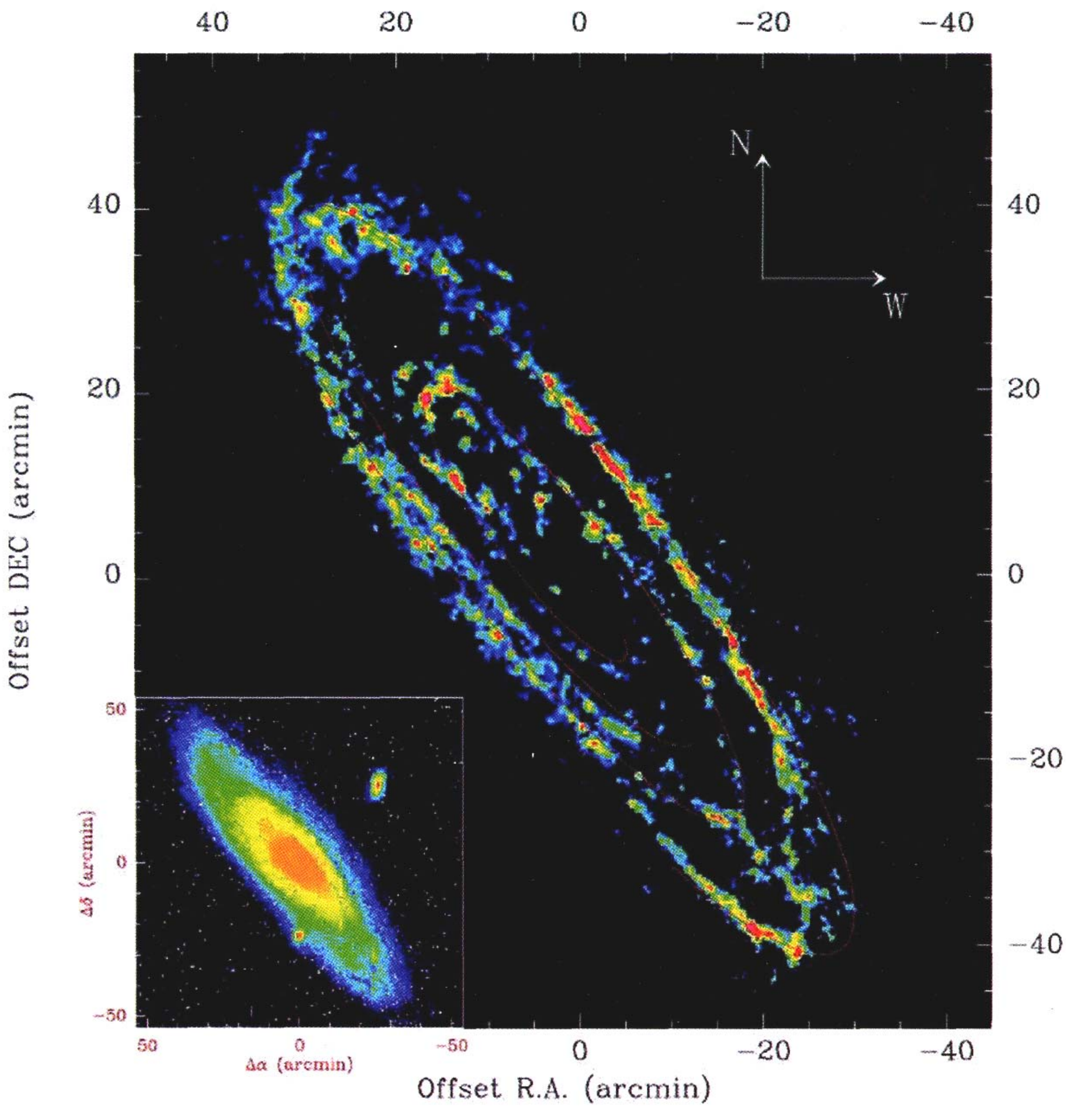

Fig. 2.4: Survey of molecular gas in M31 with the 30 m telescope. Velocity-integrated map of CO(1-0) in M31 at a resolution of 23 arcsec. The molecular gas is mainly concentrated in the thin spiral arms, with a few isolated clouds in the interarm regions. CO emission has been found between radii of 4 kpc and 18 kpc, distributed roughly in two logarithmic spirals with a pitch angle of 8 degrees in the disk plane of M31. The inset at bottom left shows a false-colour image of the visible light of the galaxy, on a reduced scale.

Comparison with maps of the atomic hydrogen shows that the CO lies in the middle of the HI arms, where velocity gradients vanish. In the western part of the galaxy, the CO arm-to-interarm contrast is about 10 to 1, much higher than for the atomic gas. No emission is found inside of a galactocentric radius of about 4 kpc at the noise level of the survey. In general, the CO survey data show that superimposed on the galactic rotation velocities, there are non-circular motions of about 10 km/s, about the same as typical CO line widths, which range from 4 to 15 km/s.

Several groups of giant molecular clouds (GMCs) had been investigated further with the IRAM Interferometer **(Fig.** 2.5). The high-resolution interferometer maps resolve the cloud complexes seen at the 30 m telescope into sub-clouds on scales of a few tens of pc, and yield different virial masses of the clouds than those based on the single-dish data alone. The virial mass estimates can then be compared with the CO line intensities and the mm and submm dust fluxes. The results of these different analyses yield refined estimates of the masses, sizes, temperatures, kinematics, and lifetimes of the molecular clouds in M31 (Neininger et al. 2002, in IAU Symposium 205, Astron. Soc. Pacific, p. 352).

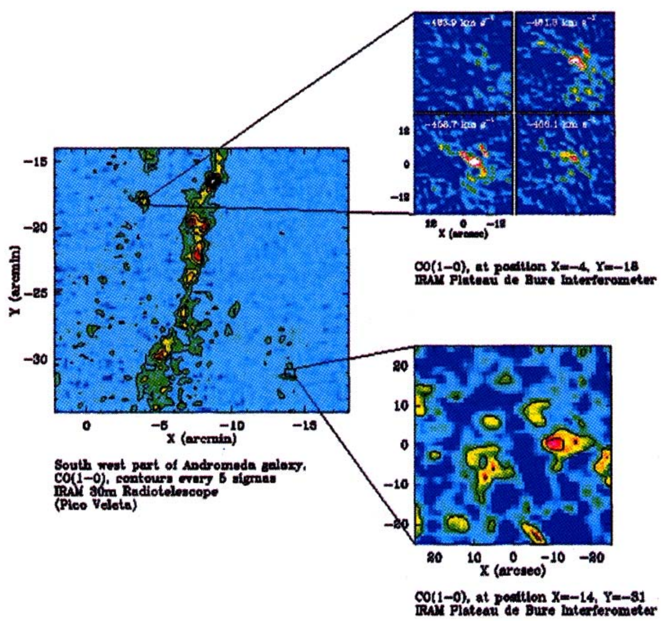

Fig. 2.5: **Molecular clouds in M31 mapped with the IRAM interferometer.** The map to the left is a section of the 30 m survey of CO in the southwestern part of M31, while the maps to the right show maps of specific cloud complexes with the IRAM interferometer. For some of the regions, interferometer data are available with a beam size of 0.9 x 0.7 arc sec, or a linear resolution of about 3.5 pc.

2.3 STAR FORMATION

The disk and jet of the high-mass protostar IRAS 20126+4124.

The luminous infrared source IRAS 20126+4124 has been mapped with the interferometer in molecular lines of SiO and methanol (CH_3OH). The maps **(Fig. 2.6)** show a compact core of molecular gas that is probably the remnant of the accretion disk around the newly-formed star. The maps also show a prominent bipolar jet of molecular gas aligned southeast-northwest. The spectral lines show a velocity gradient along the jet and also along the disk, perpendicular to the jet. (Cesaroni et al., 2003, in preparation).

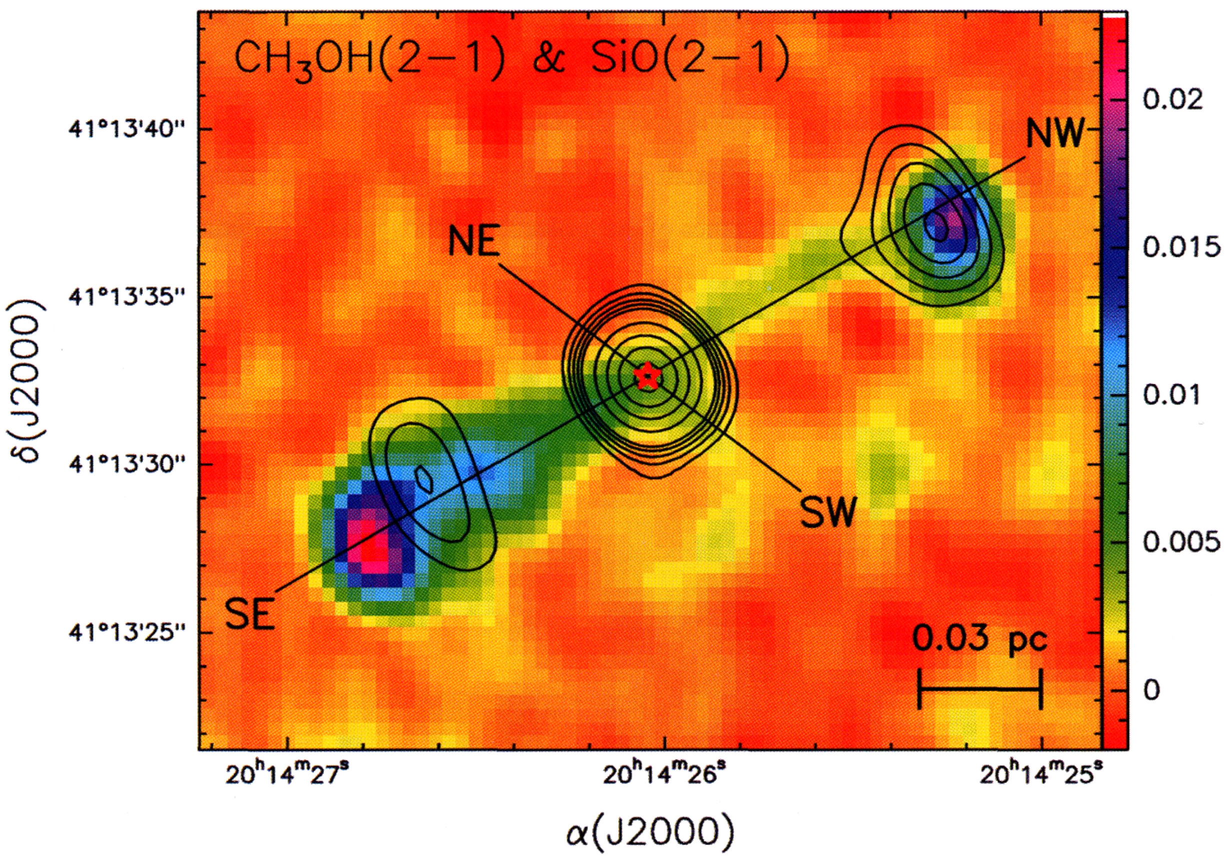

Fig. 2.6: Disk and jet from the high-mass protostar IRAS 20126+4124.
Map of the SiO (2-1) (in color), and the methanol CH_3OH (12-11) (contours) line emission. The SiO emission mainly shows the jet, probably because of the evaporation of silicate dust grains by shocks in the outflowing gas of the jet. The methanol line shows a strong concentration in the disk around the young star. The resolution is about 2 arcsec in both lines. The red star symbol marks the position of the infrared source.

2.4 INTERSTELLAR MOLECULES

Deuterated molecules and ions towards low-mass protostars.

A number of recent results from the IRAM telescopes have been published on deuterated species of interstellar molecules and ions. This new direction in deuterated-molecule research was stimulated a few years ago by the discovery of a large amount of doubly-deuterated formaldehyde in the low-mass protostar ERAS 16293-2422. In that study, Ceccarelli et al. (1998, A&A, 338, L43) found a ratio D_2CO / H_2CO of 0.05, indicating an isotope fractionation 25 times larger than in the Orion molecular cloud. Further studies confirmed the high abundance of D_2CO in IRAS 16293 (Loinard et al. 2000, A&A 359, 1169), and yielded a spatial map (Ceccarelli et al. 2001, A&A 372, 998) showing the doubly-deuterated formaldehyde was detectable up to 40 arc sec (5000 AU) from the protostar. After these confirmations, additional discoveries of large enhancements of doubly deuterated formaldehyde and ammonia were made in another, newly-identified, young protostellar core, 16293E, located in the same molecular cloud as IRAS 16293 (Loinard et al. 2001, ApJ, 552, LI63). To date, this is the source with the highest levels of double deuteration: ND_2H / NHs is 0.03, or about 6 times larger than in the previous record holder, the dense ammonia core of LI34. The D_2CO / H_2CO ratio is 0.2, about 4 times higher than in the discovery source IRAS 16293.

In the past year, further new detections have been made at the 30 m telescope, this time of doubly-deuterated methanol (**Fig.** 2.7; Parise et al., 2002, A&A, 393, L49). These authors found a ratio of CHD_2OH to CH_3OH of 0.2 , and also observed high abundances of the singly-deuterated forms of methanol, CH_2DOH and CH_3OD. An amazing result is that in the protostar IRAS 16293, the abundance of the deuterated forms of methanol is greater than that of normal methanol, CHsOH, an abundance ratio never seen before, in any astronomical source.

hi parallel with these discoveries of doubly-deuterated species, other recent studies at the 30m telescope have focussed on singly-deuterated species. Strong emission was found from deuterated ammonia, NH_2D, and from DCO^+ towards the dense molecular cloud cores LI34 and TMC1-N by Tine et al. (2000, A&A, 356, 1039). Studies of the molecular ion N_2D^+ at the 30m telescope and the Caltech Submillimeter Observatory (CSO) permitted the precise determination of the N_2D^+ hyperfine structure (Gerin et al. 2001, A&A, 551, LI93). The recent discovery at the CSO of triply-deuterated ammonia, ND_3 , in the Barnard 1 cloud emphasizes the importance of cold, high-density clouds, with no luminous stars, for producing high levels of deuterium fractionation.

What do these studies mean? Although the cosmic abundance of deuterium is low, with [D/H] ~ 10^{-5}, numerous deuterated molecules have been detected in space. Standard models of chemical fractionation in ion-molecule reactions in low-temperature interstellar gas can account for the enhancement of singly deuterated species, but do not easily explain high abundances of doubly-deuterated species. The new observations from the 30m telescope suggest that the abundance of these deuterated molecules may be (indirectly) enhanced by chemistry on grain surfaces, during the cold and low-temperature, pre-collapse phase of low-mass protostars. This may produce CO-rich ices on the grains. The exothermic reactions that enhance the deuterium species in the gas phase proceed with the help of the H_3^+ and H_2D^+ ions; the inverse reactions are inhibited because they are endothermic, needing an input of several hundred degrees K, so highly deuterated species can build up. Recombination of ions like H_3^+ with electrons or reactions with CO or other abundant species would prevent the build-up of deuterated molecules, so they may have formed in a medium strongly depleted in CO. If the CO is depleted onto the ice mantles of dust grains, this would allow the deuterium build-up to proceed by ion-molecule reactions in the gas phase. During the contraction of the protostar, the heating evaporates the CO-rich ices, liberating the CO into the gas phase again, but by then, the deuterated species have already built up to high levels and can no longer be destroyed. An important clue is that the high abundances of doubly-deuterated molecules are not observed around high-mass protostars, possibly because they get hotter and contract faster than the low-mass protostars. Whatever the resolution of these mysteries, it is clear that these new observations from the 30 m telescope are telling us something about the interstellar chemistry, about whether it happens mainly in the gas-phase or on grain surfaces, about the fractional ionisation in cold dense cores, and about the differences between low-mass and high-mass star formation.

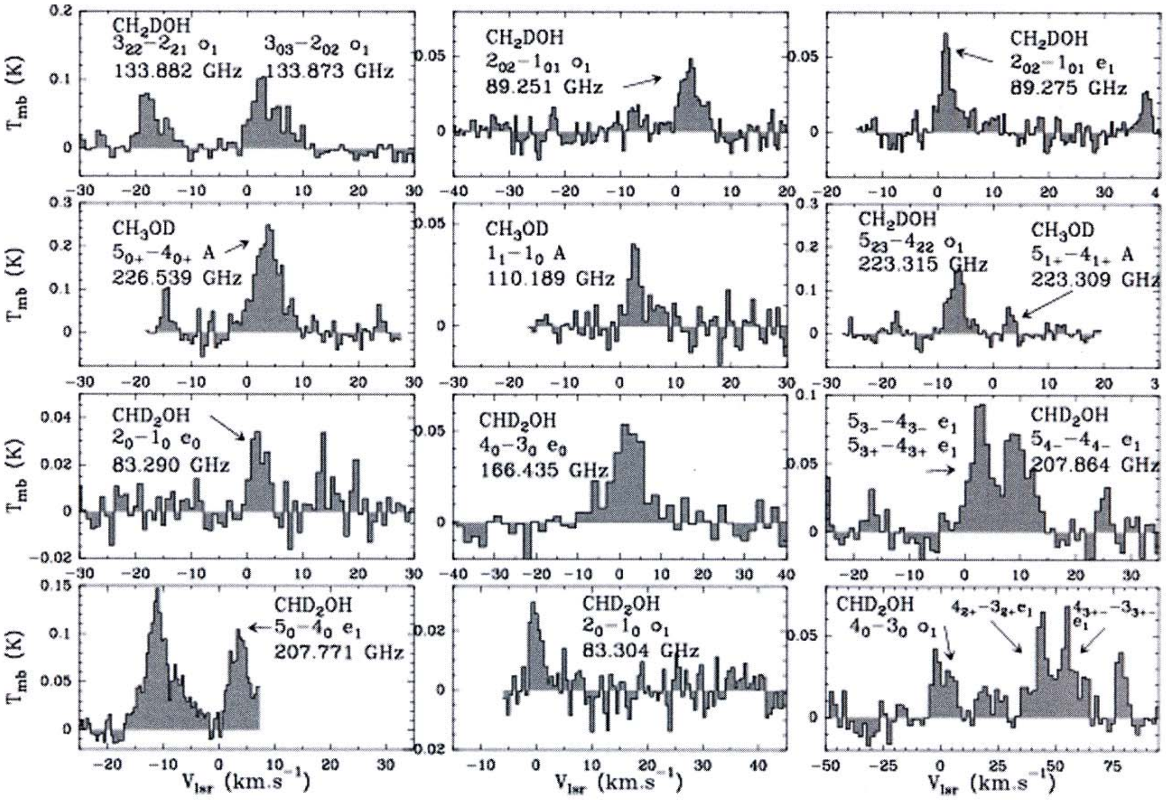

Fig. 2.7: **Spectra of deuterated methanol.** Examples of spectral lines of doubly- and singly-deuterated methanol species observed at the 30 m telescope toward the low-mass protostar IRAS 16293-2422 (Parise et al., 2002, A&A, 393, L49).

2.5 CIRCUMSTELLAR ENVELOPES AND SUPERNOVA REMNANTS

Map of CO in the circumstellar envelope of IRAS 17436+5003.

The interferometer has been used to map the CO (2-1) emission in the envelope around the giant star IRAS 17436+5003, believed to be a progenitor of a bipolar planetary nebula. When a star like our Sun becomes old, it expands, gets redder, and starts loosing mass at an increasing rate, forming a thick envelope of gas and dust that blows off into space at velocity of several km/s. At the end of this stage, known as the AGB phase, the mass loss is so large ($\sim 10^{-4}$ Msun /year) that after 1000 years, the star contracts and becomes hotter and hotter, and stops its heavy mass loss. Because this transition is very fast, only a few objects in the Milky Way are known to be at this point in their evolution. One of these objects is IRAS 17436+5003 (= V814 Her = HD161769).

As the last layers of dust and gas move away, a cavity forms around the star. This hole is shown in panel A of Fig. 2.8, which is a map of the CO emission at the systemic velocity of the star, indicated by the dashed line in panels B and C. At the same time when this cavity forms, a much lighter but faster collimated flow begins to tunnel through the envelope in two opposite directions. This bipolar flow is seen as the bi-polar "ears" in the position-velocity diagram in panel B, and as the low-intensity wings in the spectrum in panel C. (Alcolea et al. 2003, A&A, in press).

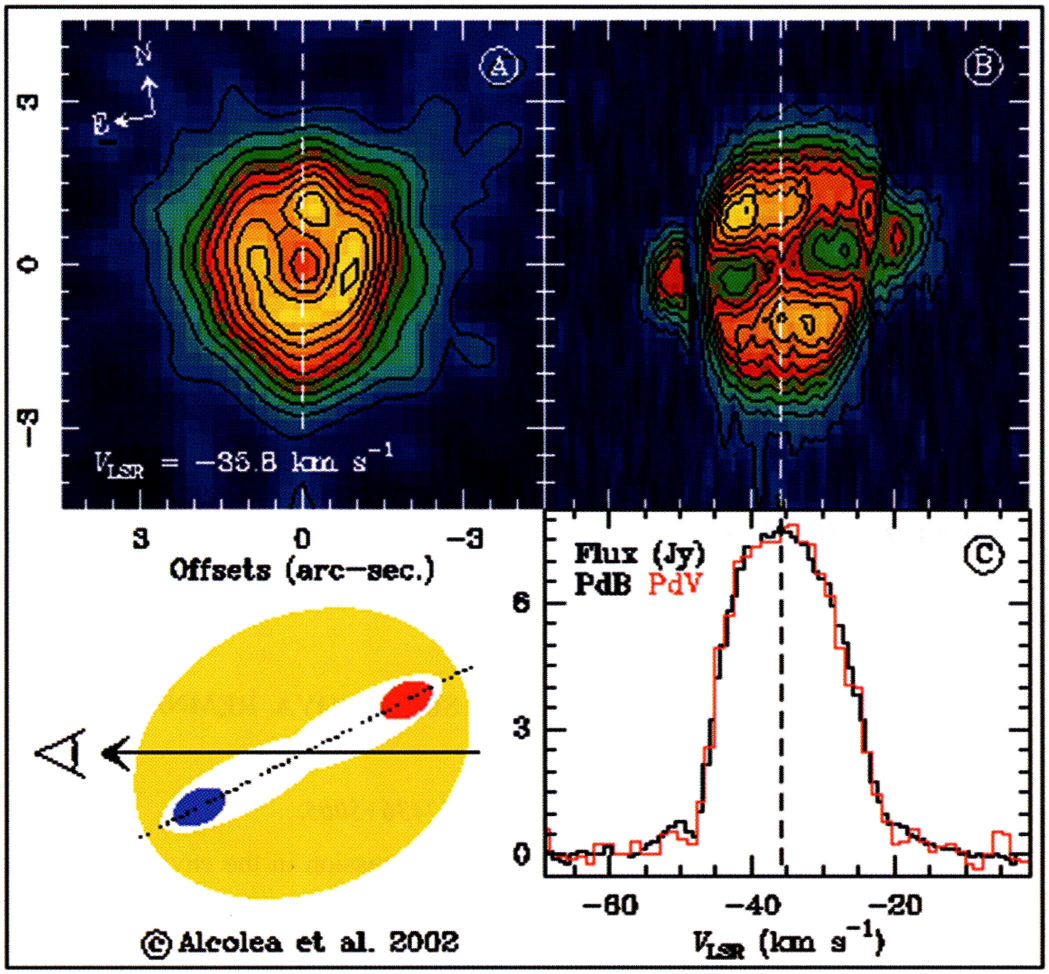

Fig. 2.8: CO in the circumstellar envelope of IRAS 17436+5003. *Panel A:* map of the CO emission at the systemic velocity of the star, indicated by the dashed line in panels B and C. *Panel B:* position-velocity diagram along the envelope's axis of symmetry (dashed line in panel A). *Panel C:* CO(2-1) spectrum from the stellar envelope; note the high-velocity wings from the bipolar flow. *Sketch at lower left:* orientation of the envelope relative to our line of sight. The diagrams shows the slowly expanding molecular gas (yellow), the central hole and cavities excavated by the jet (white), and the approaching (blue) and receding (red) fast molecular gas of the bipolar flow.

Bolometer map of the Crab Nebula supernova remnant at 1.3 mm.

The Crab Nebula has been mapped with the MPIfR bolometer arrays at the 30-m telescope. The high quality of these 1.3 mm maps allow a direct comparison with maps at cm-radio wavelengths. Comparison of the cm-to-mm flux behaviour across the supernova remnant shows a flat spectrum in the inner regions that suggests a younger synchrotron component **(Fig** 2.9), resembling that seen in X-rays, that may be the wind from the pulsar at the center of the nebula. The 1.3 mm data also show a spectral steepening in the classic radio synchrotron radiation at the position of the Crab filaments. This suggests the magnetic field in the filaments is stronger than the average field throughout the Crab Nebula, leading to greater energy losses by synchrotron radiation, and hence shorter lifetimes of the relativistic electrons in the filaments (Bandiera, Neri, and Cesaroni, 2002, A&A, 386, 1044).

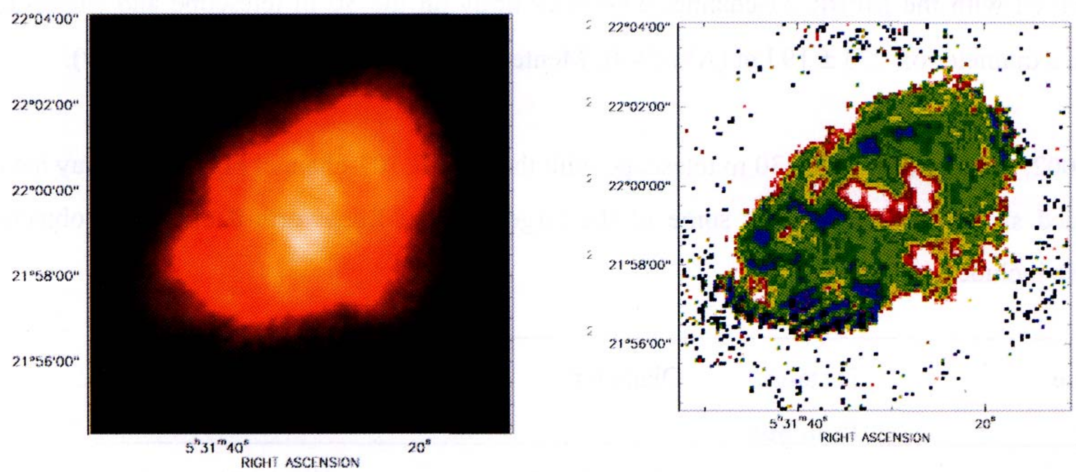

Fig. 2.9: Maps of the Crab Nebula supernova remnant at 1.3 mm. *(Left):* False-color image of the mm-synchrotron emission of the Crab Nebula, made with the MPIfR bolometer arrays at the 30m telescope. The map shows the concentration of emission near the pulsar at the center of the Crab Nebula. The region shown is 8 arcmin on a side, the intensity
^
maximum is 6.8 mJy/(arcsec) , and the beam is 11 arcsec. *(Right):* Map of the spectral index from 20 cm to 1.3 mm. The white areas indicate a flatter spectrum (spectral index -0.20) near the center of the Crab Nebula, while the blue areas indicate a steeper spectrum (index -0.3) in the filaments that may be due to energy losses of the relativistic electrons in stronger magnetic fields in the filaments. The region shown is 8 arcmin on a side.

2.6 SOLAR SYSTEM

New millimeter detections of Edgeworth-Kuiper Belt Objects.

It is currently estimated that about 100,000 objects with diameters larger than 100 km are orbiting the Sun beyond the planet Neptune in a region known as the Edgeworth-Kuiper Belt. These "planetesimals" may be relics of the formation epoch of the solar system. Their total mass is about 100 times the mass of the earth. Some of these objects (the "Centaurs") probably interacted with Neptune and got pushed from the outer belt region into the zone between Jupiter and Neptune's orbits. For the brightest of these objects, with known orbits, one may use the blackbody formula and measured millimetre fluxes to estimate sizes. The first Centaur to be observed with the 30 m telescope was the object Chiron, which was shown by Altenhoff & Stumpff (1995, A&A, 293, L41) to have a diameter of 168 ± 20 km. A second object, Chariklo, discovered with the optical Spacewatch telescope in 1997, was observed with the MPIfR 37-channel bolometer array on the 30 m telescope and shown to have a diameter of 273 ± 19 km (Altenhoff, Menten, & Bertoldi, 2001, A&A, 306, L9).

In 2002, observations at the 30 m telescope with the MPIfR 107-channel bolometer array have yielded size measurements for some of the largest of the Edgeworth-Kuiper Belt objects. These include:

Name	Distance from Sun	Diameter	Measured with
Quaoar	42 AU	1200 ±200 km	IRAM 30 m, HST
Ixion	43 AU	1055 ±165 km	IRAM30m
2002AW197	48 AU	890 ±120 km	IRAM 30m
1999TC36	31 AU	675 ±100 km	IRAM 30m

A size comparison of the largest of these objects, Quaoar, with the Earth, the Moon, and Pluto is given in Fig. 2.10 . For extensive information on the Edgeworth-Kuiper Belt Objects, see the website by D. Jewitt at http://www.ifa.hawaii.edu/faculty/jewitt/kb.html.

Fig. 2.10: Size comparison of the Edgeworth-Kuiper Belt object Quaoar with the Earth, the Moon, and Pluto. *(Montage:* NASA).

3. PICO VELETA OBSERVATORY

3.1 Staff Changes

Our last cooperant (French substitute for military service), Alexandre Duflos, who worked in the receiver group, has left IRAM. A former cooperant, Frederic Damour, was hired as a telescope operator. Ute Lisenfeld from the astronomy group left IRAM. Axel Weiß was hired as an astronomer to organize the pool observations at the 30-m telescope. In April 2002, Hauke Hein retired. He has for many years been leading the receiver group, after joining the 30-m telescope team right at the beginning. He has made substantial contributions to push the performance of the 30-m telescope and its receivers to their current high level of performance. In addition, he has for many years acted as the safety engineer on the site. A new PhD student has joined the group, Sergio Martin.

3.2 30-m Telescope Operation

About 200 astronomers came to carry out observations at the 30m-telescope in 2002. This is a similar number as in previous years. Telescope operation in 2002 was generally smooth. As shown in Fig. 3.1, almost 2/3 of the time could be used for observations.

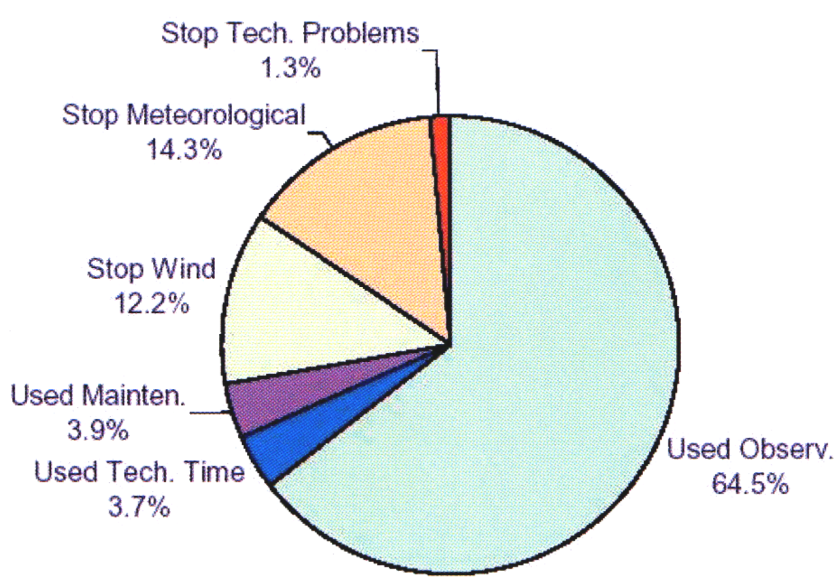

Fig. 3.1: Distribution of the total telescope time for the year 2002

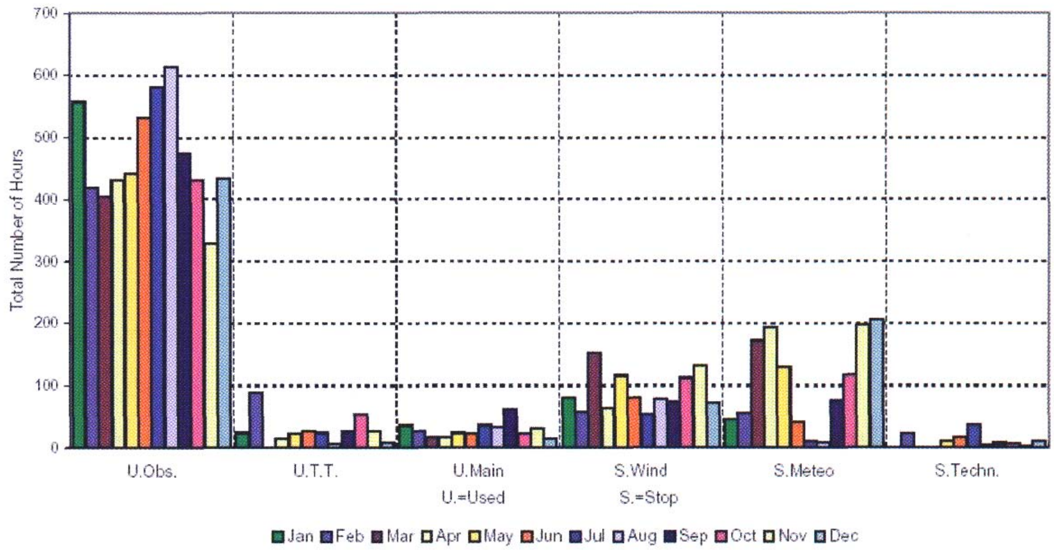

Fig. 3.2: Distribution of the telescope time in hours.

In order to increase the efficiency of the telescope, the flexible observing scheme introduced in previous years was used for most of the bolometer projects, which were scheduled during the summer and winter months. The pool observations are performed by a team of local and visiting astronomers. The pool coordinator and the scheduler have the final decision on project and source priorities taking into account the ratings of the program committee, the observing conditions and the available instrumentation.

A database has been developed to manage the projects in an observing pool. All information on projects taking part in the pooled observing mode is now stored in this database system. The database has an interface, which allows local astronomers and Pis to access and modify all information relevant to pooled observing via a web browser. A pipeline NIC reduction for bolometer observations allows a quick look at the data. It enables the user to reduce maps and on/off observations with a mouse click without downloading the data. For further analysis the PIs can download their data and logs via their web browser. A PI can provide local observers information by modifying the observing instructions or make comments for observations on individual sources via the internet. Other tools developed for pool observing provide information on visibility of sources and fluxes for all calibrators, as well as project source listings which take into account project priorities and the current weather conditions.

To further reduce the time lost because of technical stops of the antenna, a standby service on weekends has been organized in which the technical groups participate with the goal to provide competent assistance within a few hours.

3.3 Antenna

New servoamplifiers were installed in one of the two elevation groups. Antenna servoamplifiers are always in pairs in order to apply a correct anti-backslash. The new, commercially available units have improved features: they are modular and easily replaceable, the switching frequency is higher and they can provide a smoother antenna motor torque.

The initial antenna temperature control system (TCS) was a stand-alone system without any interface to the computers. A new computer monitoring of the antenna TCS now permits to relate the TCS parameters to the readings of the numerous temperature sensors distributed in the antenna. This allowed to identify the reasons of some thermal oscillations and to determine a "master temperature". After several years of studying the antenna thermal behavior and analyzing the results against a finite element model of the antenna, which has been developed for that purpose, it became evident that the main reason for the antenna astigmatism was due to the lower temperature of the counterweights (about 3.5°) compared to the antenna regulated temperature. In the fall of 2002 we therefore installed ventilators and heaters in the counterweights. Comparing the antenna behavior before and after the installation shows a significant improvement of the astigmatism, dropping the amplitude component from 89 μm to 15 μm and the total thermal deformation from 41 μm to 16 μm (rms).

After monitoring the tilt behavior of the antenna building for an extended period of time, it was decided to automatically apply the resulting changes of the related pointing constants from inclinometer readings. This, and presumably the better thermal control (see above), led to an improved pointing behavior. While in past years, the pointing constants had to be determined on a weekly basis by observations of a larger number of pointing sources, toward the end of 2002 the pointing model has become so stable that it could be left unchanged for 5 months.

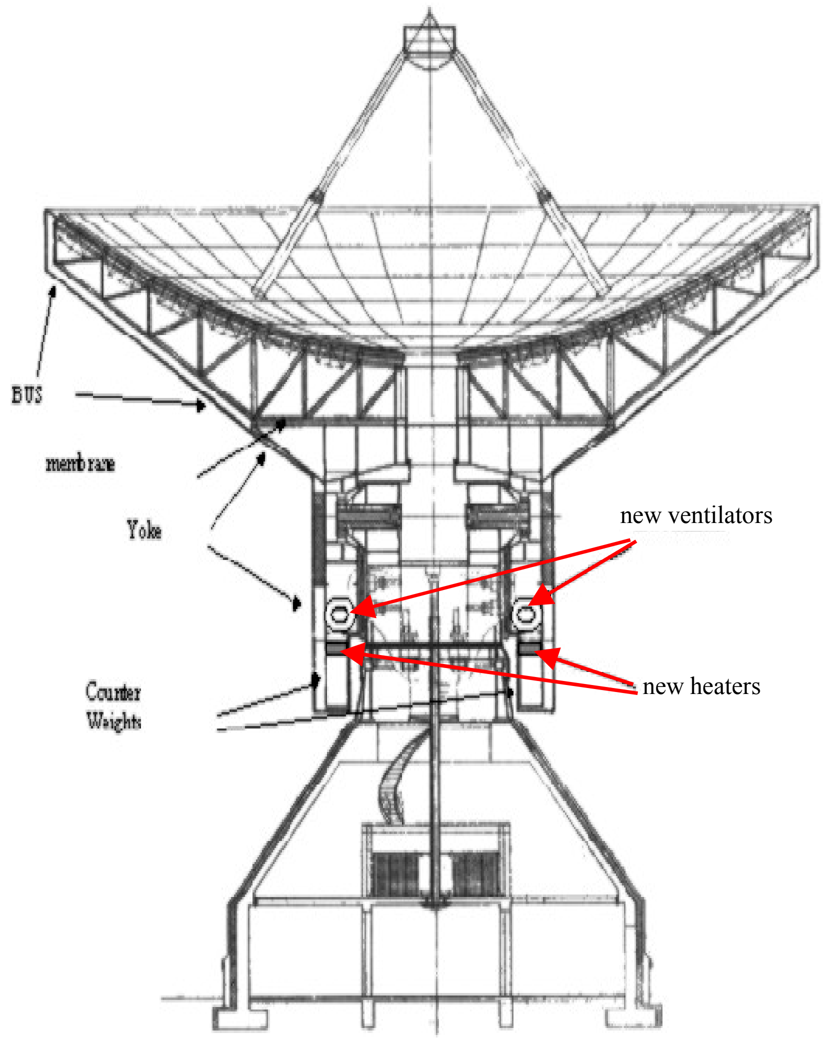

Fig. 3.3: Location of the added heating and ventilation elements in the 30-m telescope.

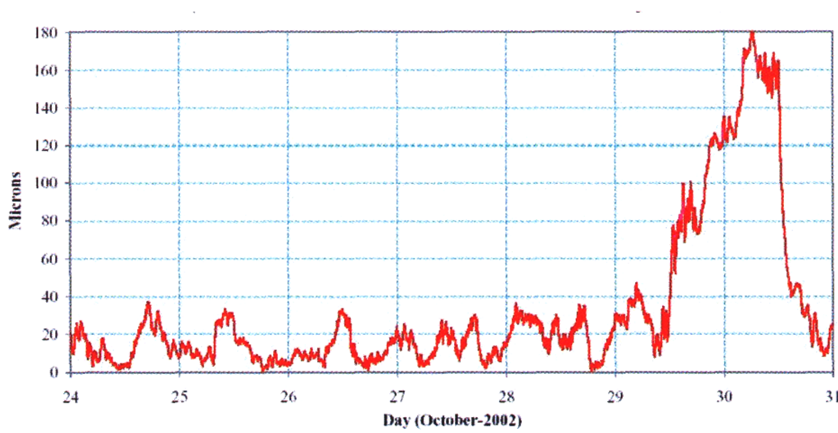

Fig. 3.4: The amplitude of the computed astigmatism of the antenna during five days of good weather (note that these values are larger than the actual rms). Up to day 29 the new temperature control system (TCS) was activated, from day 29 onwards it was deliberately switched off to show the effect of the old TCS.

The antenna group has been working on an interface for the digital communication between the computers and the Servo Control Unit (SCU). At present, this is still a CAMAC interface, which will, however, soon be replaced by VME technology. At the moment the interface is developed for the elevation and azimuth axes, while the control of the secondary mirror and the generation of alarms will be implemented in the near future.

3.4 **Receivers**

During the first quarter of 2002, a radiometer to measure the atmospheric opacity (taumeter) was successfully installed at the 30m telescope. This taumeter is needed in particular during pool observations in order to optimize the program in response to changing weather conditions. The receiver, developed at the Granada receiver lab, is located inside the air conditioning exhaust tower, on top of the main building. The system is designed around a room temperature 225 GHz Schottky mixer and includes all the necessary equipment for calibration, signal detection and data acquisition in a single rack. Receiver control is from the control room; data are displayed on a monitor in the control room and on the IRAM web page along with other weather information.

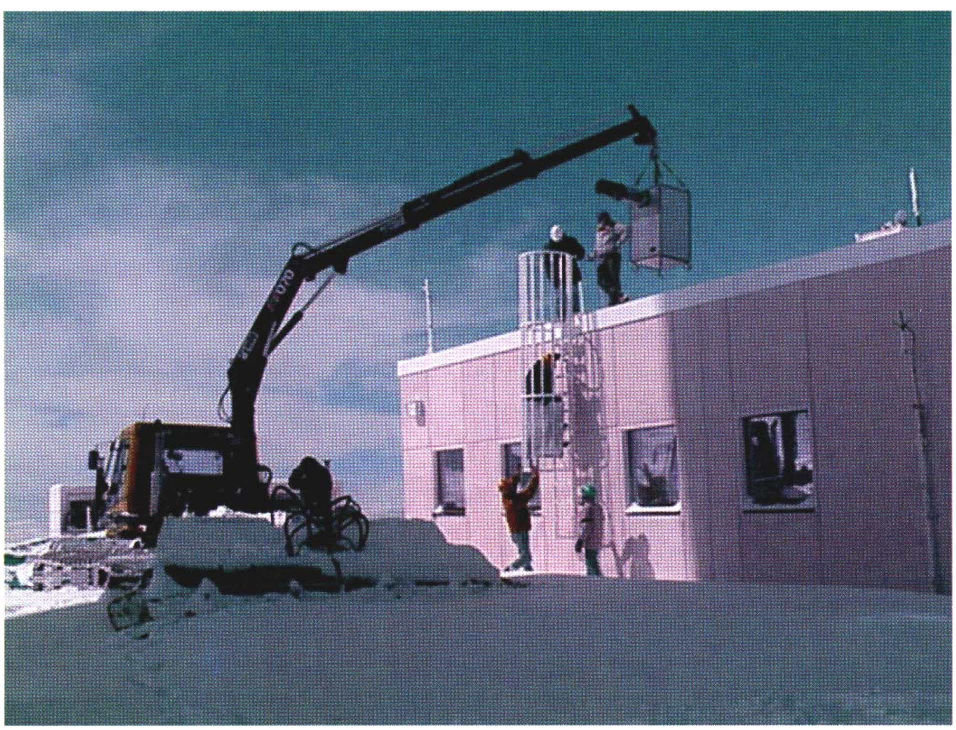

Fig. 3.5: Installation of the taumeter on the roof of the control building.

The 230 GHz multibeam receiver (HERA) is now routinely used by astronomers. Still some upgrade and maintenance work is necessary on this relatively new system. The first scheduled heavy maintenance of the Daikin cold head (performed by APD Inc.) took place. Future maintenance will be undertaken by local engineers.

In order to reduce the effects of power failures, a new UPS system has been installed inside the receiver cabin. It can supply power to the cryostats, receiver control system, VME crates and associated electronics, but it is not possible to have the helium compressors connected to the no break system because of their high power consumption.

The receiver group has also been involved in design and development work for the ALMA project, in particular in the work packages on windows and infrared filters. These tasks are almost finished. A complete set of IR filters has been sent to the Rutherford Appleton Laboratory (UK) for infrared loading measurements on the prototype cryostat. Windows and filters for the initial four bands, to be installed on the Japanese test cryostat, will follow shortly.

Fig. 3.6: Windows and IR filters for ALMA receivers.

On another, newly started ALMA related work package, IRAM collaborates with the C.S.I.C in Madrid. The aim is to demonstrate the feasibility of a new calibration scheme using a semi-transparent vane instead of the more common hot/cold load. This method will hopefully reduce possible mixer saturation on the high frequency receivers of the future ALMA antennas.

3.5 VLBI

129 GHz and 147 GHz observations

In continuation of the successful 150 GHz (2 mm) VLBI observation on the 3500 km long baseline between the IRAM 30-m telescope at Pico Veleta (PV, Spain) and the 14-m telescope at Metsahovi (MET, Finland), carried out in 2001, we have undertaken in 2002 an observation on a much longer baseline between Europe, the USA, and Chili.

In April 2002 observations at 129 GHz and 147 GHz were performed by combining the IRAM 30-m telescope, the 12-m Kitt Peak (KP) telescope (Arizona, USA), the 10-m Heinrich Hertz (HHT) telescope (Arizona, USA), the 15-m SEST telescope (Chile), and the 14-m Metsahovi telescope (MET, Finland). These experiments required close collaboration between IRAM and the Steward Observatory, the Haystack Observatory, the NRAO, the Max-Planck Institute for Radioastronomy, the Onsala Space Observatory, and the Metsahovi Radio Observatory.

The observations were successful at both frequencies, on the short baseline (200 km between HHT and KP), the intermediate baseline (3500 km between PV and MET), and on the intercontinental baseline (8500 km between HHT, KP and PV). However, fringes were not found to the SEST. On the short baseline (HHT-KP) maser sources and QSOs were detected, and on the intercontinental baseline the QSOs 3C273 and 3C279 were detected. This has set a new record in angular resolution. The data are currently being fully reduced.

CMVA observations

PV has participated in the last observations that were organized by the CMVA in spring and autumn 2002. Supported by staff from the MPIfR, IRAM participated in the autumn observations not only with the 30m-telescope, but also with the Plateau de Bure Interferometer which operated for the first time as phased array. On this occasion, also the first recordings at 512 Mbit/s were made (at PV).

3.6 Backends

The continuum detectors for the second polarization of HERA have been finished and the second detector box with another 9 channels is ready to be mounted with the additional 9 pixels of HERA 2.

The CAMAC scalers to read the backend filter banks will soon be replaced by a VME solution. A first 64-channel VME sealer module has already extensively been tested. Among other tests a manual pointing with the continuum channels was successfully performed.

In December 2002, a set of seven filterbanks with 256 4MHz channels each was installed. Now a full 1 GHz bandwidth is available for up to four single pixel receivers or with the nine pixels of the Heterodyne Receiver Array (HERA 1).

The thorough upgrade of the 4096 channel autocorrelator at the 30m telescope has been completed. The new correlator backend named VESPA (VErsatile SPectrometer Assembly) combines hardware from the old 30m and interferometer correlators into a new powerful design. The control and data acquisition software is working, and VESPA is available for general use since May 2002, giving the 30m-telescope a much needed boost in acquisition power for high resolution data. The hardware is organized in 6 units. Each digital chassis contains 12 correlation boards of 256 delay channels. A total of 18432 time domain channels are now available. With two synthesizers installed in each unit, a large range of spectral resolutions and bandwidths has become possible, increasing the correlator capabilities by a factor of three in most configurations. In its highest resolution modes, VESPA can reach an unprecedented velocity resolution of 10 m/s at 100 GHz. It also has the capability of being used as an IF polarimeter.

Figure 3.7: VESPA in the backend room at the 30m telescope. This correlation spectrometer consists of 6 units, each having a digital chassis with 12 correlator boards and an analog chassis with 15 RF modules.

3.7 **Computers and Software**

A new remote observing station was installed at the Observatorio Astronomico Nacional of the IGN in Madrid. The remote observing station in Paris was reviewed in August and the Grenoble remote observing station that was running on a HP Unix system is now running under a Linux system. A total of five remote stations are now operational: Granada, Madrid, Bonn, Paris, and Grenoble.

In cooperation with the IRAM Headquarter staff in Grenoble, IRAM's web pages have been redesigned and the new format implemented. There is one web server in Grenoble and one in Granada, and both serve as mirror sites for each other.

At the observatory, the main file-server and a powerful system for data analysis have been installed. These two systems are linked by a 1 GBit Ethernet interface. Work on a third system has started that will serve as a backup system for the file-server, the data processing system, and also the web server.

For the New Control System (NCS) for the 30m telescope, the system design was revised and elaborated. Work on software for several subsystems has started or was continued. Closely related to this are various upgrades of hardware components. An updated overview of the system architecture can be found on the IRAM Granada web pages.

Prototypes for the future user's interface have been written for various observing modes. This includes general defaults, limit checks, check for standard ranges, save to file and restore for each mode, and a graphical preview. Prototypes for the subsystems scanAnalyzer and coordinator were tested for a limited range of observing modes. Software was developed and tested with the new hardware for the control loops for antenna movements in the azimuth and elevation axes. The software development for the new VME digital interface for the Servo Control Unit has started. Prototypes for the "coordination layer" and device control were written.

Together with the installation of VME hardware for the continuum backend and the new 4MHz filter banks for heterodyne receivers, software has been installed which already takes into account the plans for the NCS.

An online data processing software has been installed on the Linux file server. It supports the main observing modes used with the spectrometers. In particular, it does automatic calibration of On-The-Fly observations and for data from the 4MHz backend. The mayor release of the online data processing software that should be ready in the autumn of 2003 will process also continuum data.

Members from the IRAM computer group in Granada attended an ESO training course on Alma Common Software.

3.8 Infrastructure and Safety

For safety reasons we were obliged to replace the spiral staircase in the Granada office by a more conventional one.

The access road to the observatory had to be repaired after it suffered severe damage due to heavy rain. Two retaining walls with a length of 20m and a height up to 1.5m were constructed, each made of reinforced concrete and stones. The drainage along the street was improved to avoid future damage.

Fig. 3.8: The improved access road to the Observatory

A new Diesel generator has been installed at the observatory to guarantee a reliable supply of power. Previously, there were two smaller generators working in parallel with a maximum total power of 170 kW, while the typical observatory consumption fluctuates between 160 and 210 kW. This consumption practically has not changed since the starting of the observatory. The new generator can deliver up to 320 kW which is sufficient for the normal operation, including a minimum antenna deicing capacity during bad weather conditions in winter.

Fig. 3.9: Installation of a new Diesel generator

A new electrical switching box in the BE-Computer room permits the complete isolation of 32 electrical circuits for computers, BE, control desk, offices etc. Each circuit has its own differential and thermal protection. Previously, several electrical circuits shared the same differential protection. This could lead to an interference of the general electrical system with e.g. the electrical supply of critical computers.

After tests had shown that the operation of mobile phones within 100m from the backends can cause interference with the filterbank backends, their use inside the control building and in the telescope has been forbidden.

3.9 Other Activities

The IRAM-Granada staff supported the organization of an ALMA working meeting that was attended by more than hundred participants.

4. PLATEAU DE BURE OBSERVATORY

4.1 Staff Changes

Following a reorganisation of the Plateau de Bure management structure, Bertrand Gautier was assigned as station manager of the Plateau de Bure Observatory in April 2002. He shares his time between the Observatory and the IRAM Headquarter at Grenoble where he leads the management team that was created to provide operational support the Plateau de Bure activities.

4.2 Observations

General Observing

The six-element interferometer has now been in operation for roughly one year with almost no downtime caused by equipment failure during scheduled observations. The receivers all performed well throughout the year without significant problems. The weather conditions on the site were excellent in January, conditions were relatively good from spring to fall, and poor in February and November.

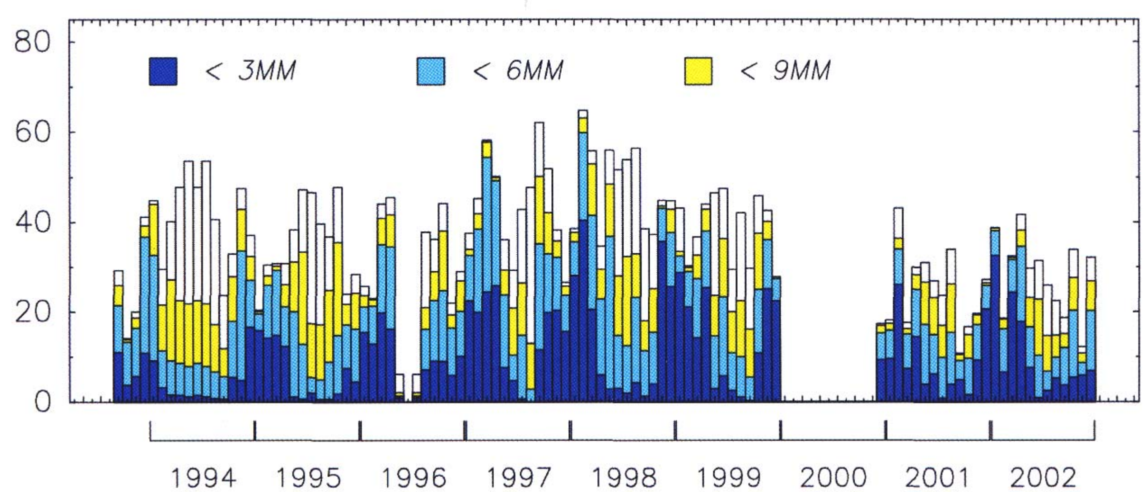

Fig. 4.1: The atmospheric water vapour content recorded on the Plateau de Bure since August 1993. Observations in the high frequency window (202 to 245 GHz), and observations in extended configurations are for the most part carried out in the winter months.

The percentage of total telescope time scheduled for astronomical observations was on average about 30 percent of the total time in the winter months and lower in the summer because priority was given to maintenance work. An additional 10 percent of time went into astronomical test measurements for holography, VLBI testing etc. The remaining time was lost due to bad weather conditions.

Despite the limited total number of people working at the Observatory, and the constraints that this puts on configuration changes, an effort was made to schedule the B configuration in wintertime, in addition to the C and D configurations. The scheduling of an extended B configuration has been very important for the scientific return of the interferometer. As last year, a large amount of observing time was invested in D configuration observations between spring and fall in an attempt to detect CO line-emission from high-redshift galaxies.

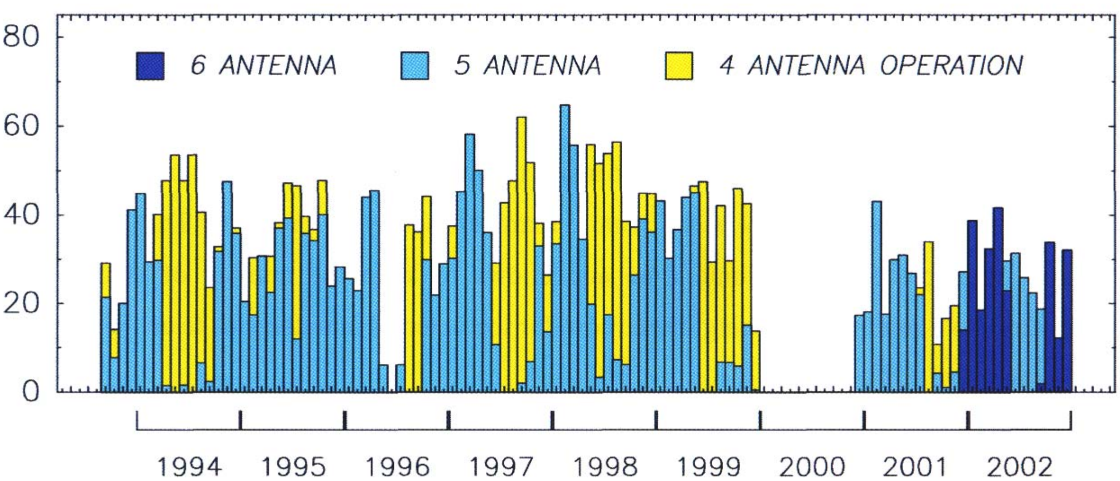

Fig. 4.2: The percentage of time used for astronomical observations since August 1993. From May to October observations are in general made with a subset of the interferometer. This period coincides with the annual maintenance period. Antenna 5 became operational in the summer of 1996, Antenna 6 at the end of 2001. As a consequence of the accidents, observations had been stopped from December 15, 1999 to December 1, 2000.

The scientific output of the interferometer was again high: about 100 different observing projects were scheduled at the Observatory in 2002, with the emphasis on extragalactic science. Details of the accepted scientific projects are given in Chapter 7.2.

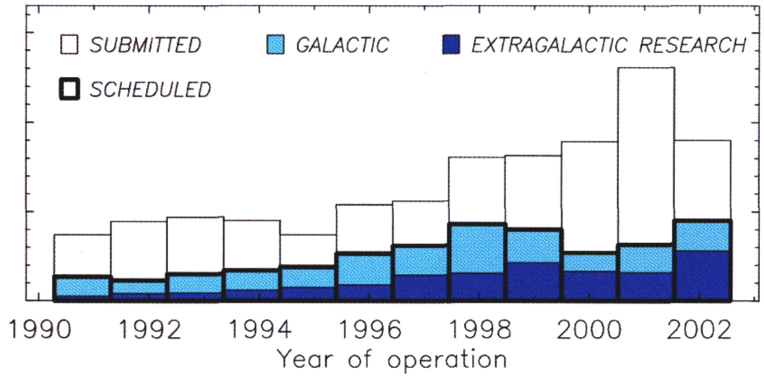

Fig. 4.3: Evolution of the number of scientific proposals for the Plateau de Bure Interferometer since May 1990 and up to May 2002. The average pressure factor is higher than two. Note the steadily rising interest in extragalactic projects.

The first and the last week in October were entirely devoted to the commissioning of the 3mm VLBI observing mode of the interferometer and to first coordinated millimetre VLBI continuum observations together with radio observatories in Europe and in the United States. A status report is given below.

During the period from May to November many regular scientific observations were carried out with an astronomer on duty at the remote terminal facility in Grenoble. This possibility has now been practiced for some time and allows to keep the number of staff at the Observatory to a minimum, leaving more room for the external maintenance teams during the summer months.

VLBI observations

In July 2002, the terminal, maser, formatter, decoder, and the FS9 system were transported by helicopter to Plateau de Bure (PdB, France), after extensive tests of the equipment had been made in Grenoble.

In October 2002, with crucial support from the VLBI team of the MPIfR, test observations at 3 mm were successfully made between the PdB and the Effelsberg telescope. The 30m-telescope should have participated, too, but suffered from bad weather conditions on Pico Veleta at that time. In this experiment, the 6 antennas of the interferometer were in the most compact configuration and the array was successfully phased to one reference antenna.. The test has demonstrated that the Bure interferometer can work as a phased array at 3 mm wavelength, and certainly also at 1 mm as will soon be verified.

Given the fact that the test has been a success, the PdB Interferometer participated for the first time as a phased array in CMVA observations, again with the support of staff from the MPIfR.

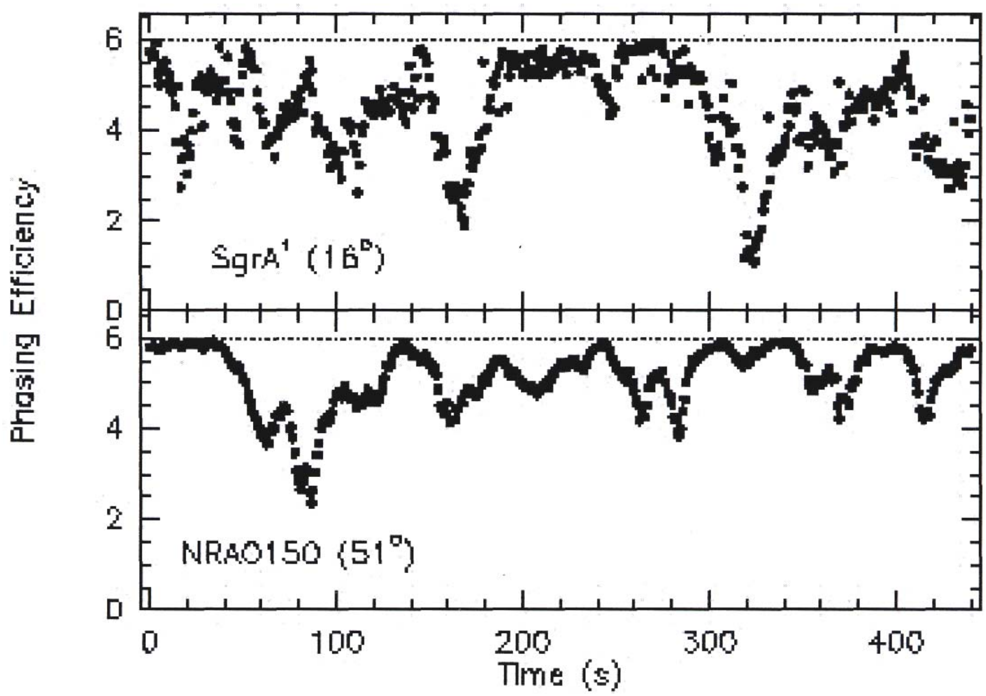

Fig. 4.4 : Results from the VLBI observations that involved the PdB Interferometer for the first time as a phased array. The figure shows over a period of 7.5 minutes the phasing efficiencies at 3 mm for the source SgrA*, at 16 degrees elevation, and for the QSO NRAO150, at 51 degree elevation. In the absence of atmospheric phase noise, the efficiency would be 6 according to the 6 antennas being phased.

Calibration

Substantial work was made to improve the smoothness of the calibration pipeline, on optimising the observing strategy of flux calibrators, and gathering first detailed information on the 22 GHz radiometers. A new automatic calibrator observing procedure was established that improves the reproducibility of the calibration accuracy, secures a reliable data reduction, and will give, in the long-term, improve the quality of the flux calibrator database.

Data archive

Work to provide a Web-based access to the entire Plateau de Bure Archive was progressing well. By June 2002, the Archive already contained the years from 1996 to 1999, and was heading towards completion at the end of 2002. The database, which is a collaborative effort with the Centre de Donnees Stellaires in Strasbourg (CDS), is planned to go online by 2003. A web-based tool for searching the Plateau de Bure Archive will be available in the near future.

4.3 Configuration studies for the PdB array including baseline extensions

Early in 2002, efforts were made to extend the current set of configurations for the six-element interferometer. A new configuration dubbed A-configuration was designed that provides highest angular resolution and high-brightness sensitivity when combined with the B configuration, and minimum antenna position changes to limit snow-clearing activities on the site. These requirements have led to the selection of four array configurations for the winter 2002/2003 observing period. While giving significant advantages, this set of configurations is not definitive and will be changed again when station N46 on the northern track extension will ultimately become available.

In connection with the long-term plans to extend the capabilities of the Plateau de Bure Interferometer, a new development project was started in the course of the summer: the extension of the Eastern track from now 408m to almost 800m (see Figure).

Detailed investigations of the geological properties of the soil have already been made: more than 13000 m^3 of rock material will have to be moved to create a flat area of 3500 m^2 on which the antennas would be moved to reach the end of the Eastern track.

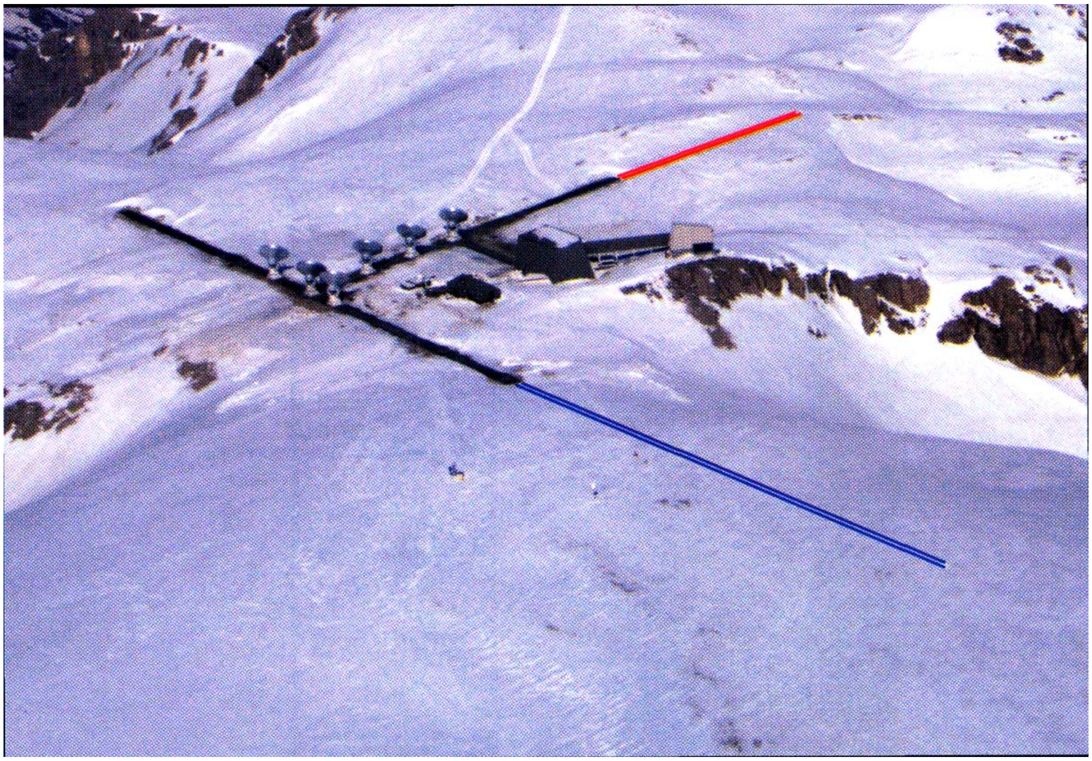

Fig. 4.5: Aerial view of the Plateau de Bure Interferometer in its D configuration. The northern track extension (red), which is awaiting completion, and the planned extension (blue) of the eastern track are expected to double the current angular resolution capability of the interferometer: astronomical targets will then be mapped with a 0.3 arcsec resolution at the frequency of the CO(2-1) line.

4.4 Technical Maintenance Work

Completion of the work on Antenna 6

The commissioning of Antenna 6, which has essentially been carried out in January, has mostly focussed on adjusting the primary surface, on removing important instabilities in the tracking, and on verifying antenna performance and general reliability. After a few initial surface readjustments verified by holographic measurements, the surface accuracy of the new antenna was found to be better than 70 microns (see Figure 4.6). The tracking control system was significantly improved during the summer maintenance and is now providing a tracking accuracy better than 0.2 arcseconds (rms). Motivated by the excellent tracking performance of this antenna substantial work is now planned for next year to refurbish the tracking control system of all other antennas. The dual-channel receiver of Antenna 6 is working according to specifications and without noticeable problems since its installation.

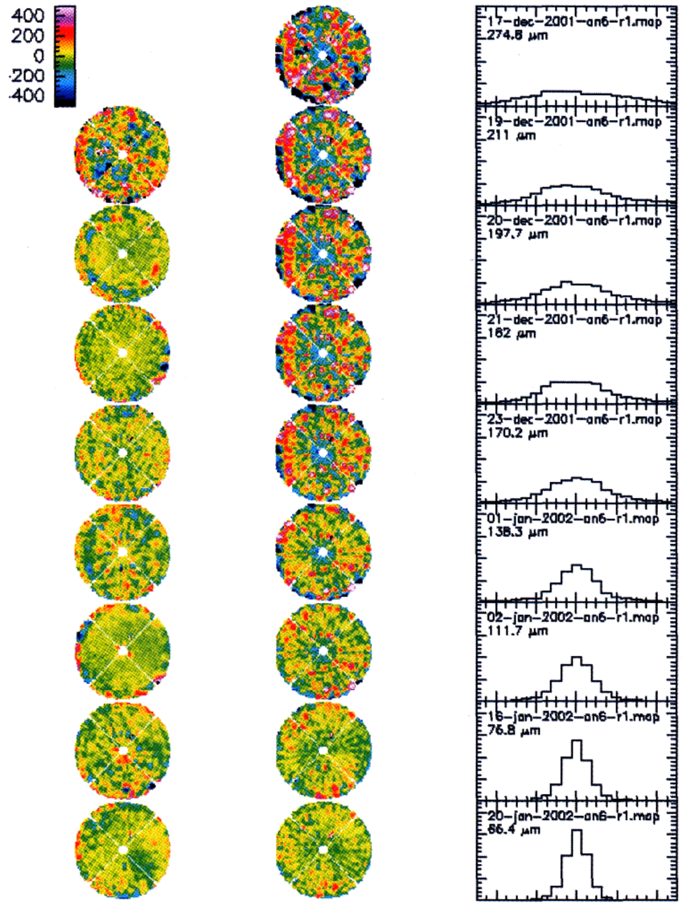

Fig. 4.6: Surface accuracy achieved on Antenna 6 since December 17, 2001 and after seven holography iterations: panel corrections after each iteration (left column), panel distribution according to holography results (central column), surface rms (right column).

Regular maintenance work

As in previous years, the maintenance of the interferometer was carried out during the summer. The "Cellule Bure", the Observatory's management team located at the Grenoble headquarters, coordinated activities related to the maintenance, organized the training and working schedule of personnel recruited on short-term contracts, scheduled transports by helicopter or transports on ground, provided assistance to the Observatory staff when needed and coordinated technical activities. The group also helped to establish technical procedures that have resulted in a more efficient overhaul schedule, and to purchase critical spare parts and materials to support antennas and instruments. Despite the many different technical activities and a first and careful inspection of the mechanics and of the painted surface panels of antenna 6 after a first winter of continuous operation, the total time for maintenance work could be reduced to five months.

As in previous years, the antennas that still have Hostaflon covered carbon fibre panels have carefully been inspected for new pinholes. A few thousand stickers had to be glued on Antennas 1, 2 and 4 to avoid a further degradation of the surface, and a few panels had even to be replaced on Antenna 2 and 4 because of significant reflectivity losses. The surface of all antennas was readjusted in the fall and verified with holographic measurements. According to the final analysis, the surface accuracy of all six antennas is now in the 40 to 60 micron range for the inner four rings, and 10 to 30 micron higher for the outer two rings. Two aluminium subreflectors with an optical quality better than 10 microns (rms) were installed on Antenna 1 and 4 to replace the Hostaflon covered carbon fibre subreflectors that have started to show first signs of delamination. Only Antenna 5 is still equipped with a carbon fiber subreflector.

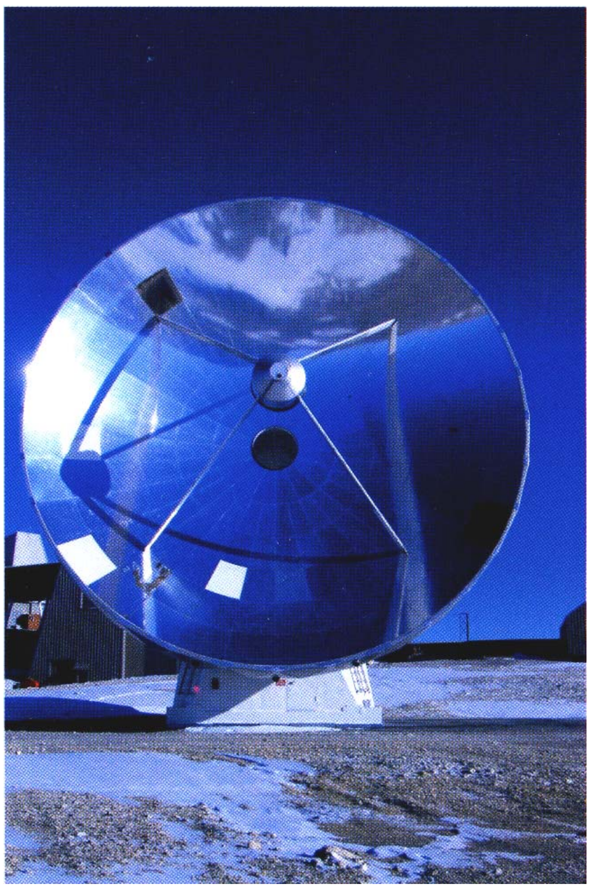

Fig. 4.7: The surface of Antenna 1 with three panels replaced during the summer maintenance. These are carbon fiber panels with a reflective layer of silver paint, and a protective cover of white paint.

4.5 New technical installations

Fiber optic cables

The need to replace the LO signal transport system in order to have the capability of wider-bandwidth and a more reliable performance, has led IRAM to explore a solution based on fiber optic cables. The new generation of receivers will deliver signals sampled at 4 GHz RF bandwidth that need to be interfaced over distances of several hundred meters. The major goal for 2002 was to equip a limited number of stations and of correlator entries with fiber optic connections, and to prepare the installation of the prototype electronic system in two antennas for tests in the spring of 2003. By September 2002, 6 stations along the northern, western and eastern arms had already been equipped. Work on the remaining stations will be completed in 2003. Work on the correlator and on the prototype electronics was slightly delayed, but was progressing well by the end of 2002.

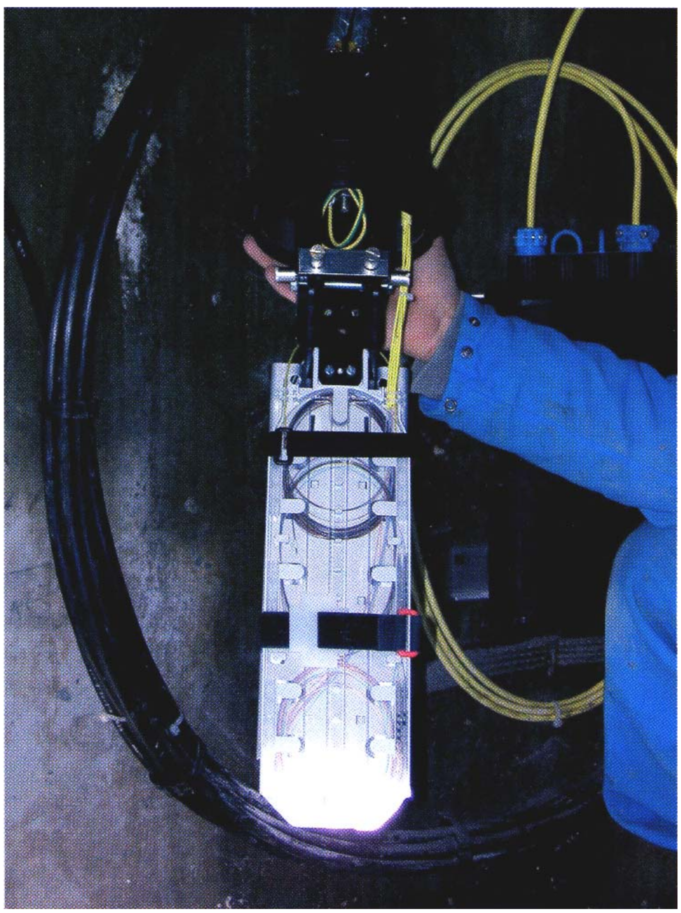

Fig. 4.8: View of the waterproof fiber optic connector installed in the stations. At this, 6 fibers are actually arriving at each station. This number can be increased to 10 if future generations of receivers require this.

Computer resources

Work has been continued to increase operational reliability. A redundant computer for data reduction was installed to allow almost instantaneous switch-over in case of failure of the main system. This operation, which guarantees much better system reliability on the long term, was carried out in poor weather conditions to minimize the downtime for astronomical observations, and extensively tested since its installation.

The 22 GHz radiometric phase-correction system

Two additional antennas (4 and 6) were equipped with 22 GHz three-channel radiometers, and two (1 and 3) remain to be equipped in 2003. The receivers are used to correct for wavefront distortions caused by moving cells of atmospheric water vapour. The radiometers have a three-channel discriminating system to detect emission from water vapour while rejecting spurious emission from cloudlets and water droplets. The technical group has made excellent progress in stabilizing the temperature of the receiver cabins to ensure that electronic stability matches the expected performance of the radiometers. This is a necessary condition to use the systems to correct for phase decorrelation. In December, work on the thermal stability of the radiometers was almost completed: thermal leaks in the receiver cabins were removed as far as possible, and new ventilator-heater systems installed in all cabins. The achieved performance of the systems will be closely monitored during 2003.

Infrastructure, safety issues and other site activities

Many maintenance aspects of the buildings have been checked, and improvements have started during the 2002 summer period. The most important ones are described below.

- Renewal of the POM2 building

An agreement was signed with the Université Joseph Fourier which enables IRAM to use the POM2 building. As it had been out of use for several years, a complete overhaul was necessary, including a renewal of the plumbing and painting. Four more beds are now available for visitors. Subcontractor staff that has to stay on the Plateau de Bure for longer periods of time is accommodated in these rooms.

Fig. 4.9: View of one of the two bedrooms in the POM2 building. Each room can be equipped with two beds.

> Renewal of the gallery

The gallery between the hall and the upper cable car station requires substantial repair work. The rust was removed from the structure and the complete building has been painted during the summer period. The water tightness has been improved. Further work is planned during the spring of 2003. A major item will be the repair of the ground of the gallery.

> Further improvements in safety

All electrical installations on the Plateau de Bure (stations, antennas and buildings) have been checked by a certified firm and the recommended changes have been implemented in the meantime. The mechanical safety has also been checked during the 2002 summer period. As a result, the scaffoldings for antenna maintenance have been modified (the mobile steps), and protections have been added at the top of the workshop building to prevent falling.

Fig. 4.10: View of the inner part of the gallery during the summer maintenance work.

4.6 3rd Summer School on Millimeter Interferometry

Following the success of the first two summer schools, a third IRAM School on Millimeter Interferometry was organized with the financial support from the European Commission and the CNRS. The 2002 summer school took place from September 30 to October 5, at the IRAM headquarters in Grenoble. The school consisted of a series of lectures presented by in-house and invited experts, and practical exercises in order to familiarize the participants with all phases of the observing, data reduction and data analysis process. The number of participants was limited to 65 with a good mix of students, postdocs and experts in other branches of astronomy, from Europe and overseas. The participants were invited to contribute as much as possible with posters describing research conducted at interferometers worldwide.

5.1 SIS GROUP ACTIVITIES

The activity of the SIS group during 2002 has focused on the preparation of large-scale device production for the upcoming and demanding projects like the next generation of Plateau de Bure receivers, and the ALMA Band 7 mixers. For this purpose the group has upgraded and completed its equipment and continued process development.

SIS junctions have been fabricated for IRAM 230 and 350 GHz mixers foreseen for the 30m telescope and the Plateau de Bure Interferometer. Junctions for the HIFI instrument (for Channel 1, 480-640 GHz) on the HERSCHEL space mission have been optimized and produced. Yield and device parameter tolerances have been greatly improved **(Fig.** 5.1). The produced devices are used to fabricate the DM mixers (demonstration model) and will also be used for the QM and FM mixers (qualification and flight model). The junctions underwent an extensive space qualification procedure, including thermal cycling, rapid aging and electro static discharge tests.

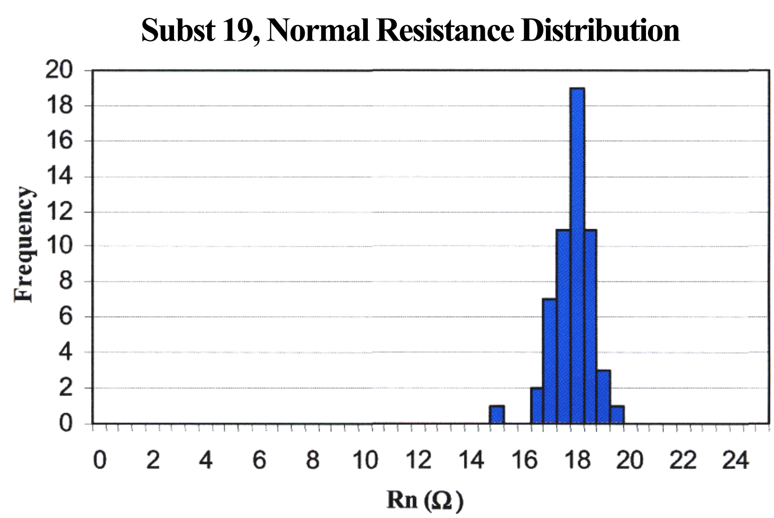

Fig. 5.1: Statistical distribution of the normal resistance of devices including two lum^2 junctions in parallel. Under the assumption that the spread is entirely due to size variations an area homogeneity of better than 7% or a linear dimension variation of 35 nm can be derived.

One of the largest investment projects of the last years has been the recently purchased inductively coupled plasma etching machine (Alcatel 60IE) which was delivered and installed towards the end of 2002. A Niobium etching process was developed in collaboration with Alcatel Vacuum Systems. With this process the equipment allows new levels of dimensional control during structure transfer and also enables etching of thicker Niobium films with high anisotropy. This will lead to improved device characteristics and reduced process complexity. The machine is fully programmable and with the advanced endpoint detection system the etching process has gained speed and reliability. Moreover the new ICP equipment with its deep Si etching capabilities also fully supports the recent IRAM RF-MEMs development as well as new and advanced concepts for FIR passive and active devices.

Fig. 5.2: Test pattern of Si micro machining with the new Alcatel ICP equipment

Work on Aluminum-Nitride was continued. Aluminum-Nitride is a material with increasing importance for thin film technology and a wide area of applications. Extensive studies on sputtered AlN films were performed during the last year. In addition the sputter equipment has been modified to allow the *in-situ* formation of AlN and NbN as ultra thin layers by means of plasma nitridation. While AlN serves as tunnel barrier for high current density tunnel junctions, the surface nitridation of Niobium films helps to suppress film oxidation and parasitic contact resistances.

A new automatic Tc-measurement setup was built which allows the rapid and precise measurement of the critical temperature (Tc) of superconducting thin films as well as their residual resistance ratio.

The development of RF-MEMs has been pursued. Numerical modeling of the electromechanical characteristics has been made with various finite element programs and the particular problems of differential stress in films, which are sputtered on sacrificial layers has been analyzed.

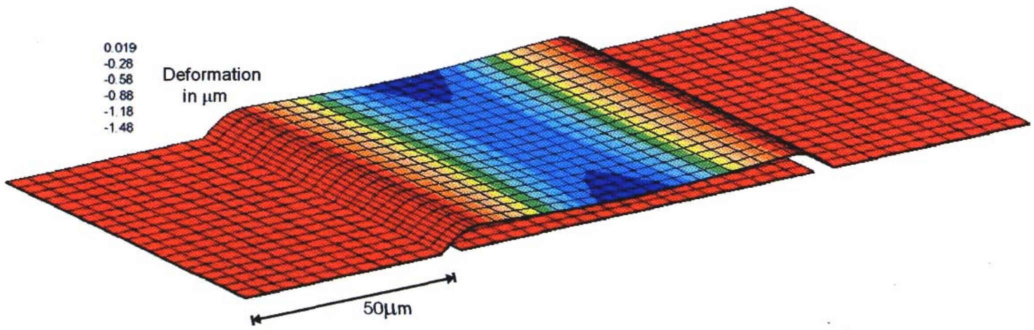

Fig. 5.3: Finite element simulation of a variable capacitance air bridge system from Niobium with an applied voltage of 80V. The calculation clearly shows the necessity of 3-D modeling.

The SIS group has organized a workshop on the issues of lithography in small laboratories. The workshop found good resonance from other laboratories in the Grenoble area and will be repeated next year.

5.2 RECEIVER GROUP ACTIVITIES

5.2.1 Receiver construction and maintenance

HERA (1.3mm Multibeam) second polarization

The receiver group is responsible for the construction of the RF head for the nine pixels of the second polarization of the 1.3mm multibeam receiver. That receiver is currently available at the 30-m telescope in single-polarization mode.

All the mechanical parts have been received and assembled. The wiring —bias for mixers and cryogenic IF amplifiers, temperature sensors—, totaling about 100 wires with thermal shunts, has been nearly completed in 2002. All nine warm IF amplifier modules have been completed. Several problems that have been found with components have delayed the completion of the local oscillator. The mixer blocks are ready. The line injection system has been designed and installed into the currently used LO box. It will be used to improve the sideband calibration accuracy of HERA.

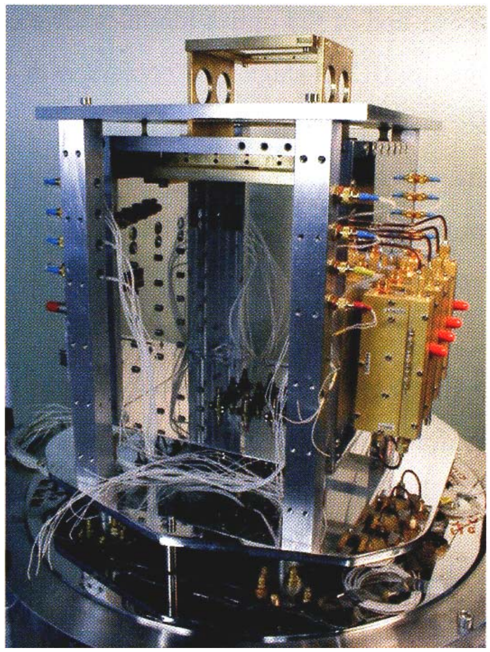

Fig. 5.4: The nine-pixel RF module for the second polarization of HERA during construction.

22GHz water vapor radiometers for PdBI

Four more radiometers have been completed, reaching the goal of seven in total (six antennas and one spare). All the radiometers have been verified in the laboratory to perform according to technical spefications. Two radiometers have been installed on antennas 4 and 6, reaching a total of four equipped antennas on site, available for system tests by astronomers. In order not to interrupt the astronomical observations during winter time, further installations have been delayed.

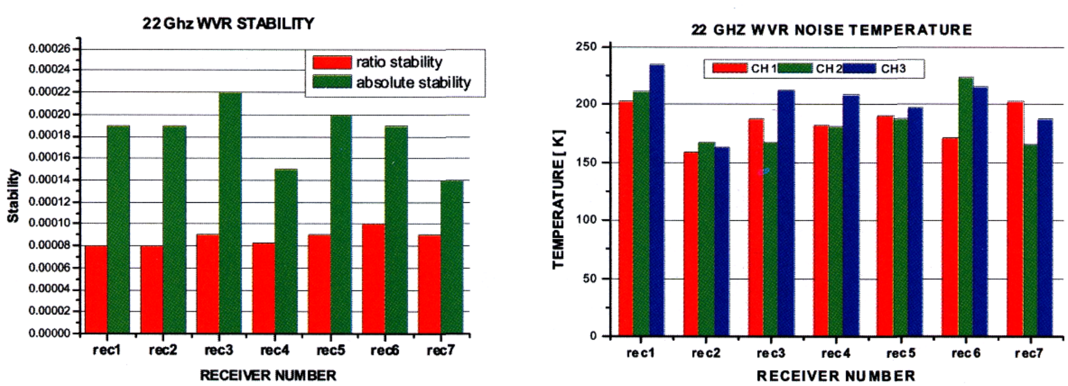

Fig. 5.5: Summary of laboratory tests of the seven 22GHz water vapor radiometers.

Plateau de Bare new generation receivers

Design studies have been continued. Outside firms have been contracted for the detailed mechanical design of the dewar and of the optics modules. The choice of the cryocooler has been re-assessed, and changed to SHI 3-stage GM coolers with He pot option. This has the following main advantages: a) avoiding the potential clogging problems of the JT valve, b) European-based maintenance and technical support, c) equipment identical to what is foreseen for the ALMA project, d) possibility to reach a temperature below 4K, with a potential for a reduction in receiver noise.

The optics design has been finalized. Horns for band 1 (λ 3mm) have been designed, made, and tested, including a novel design with integrated waveguide twist.

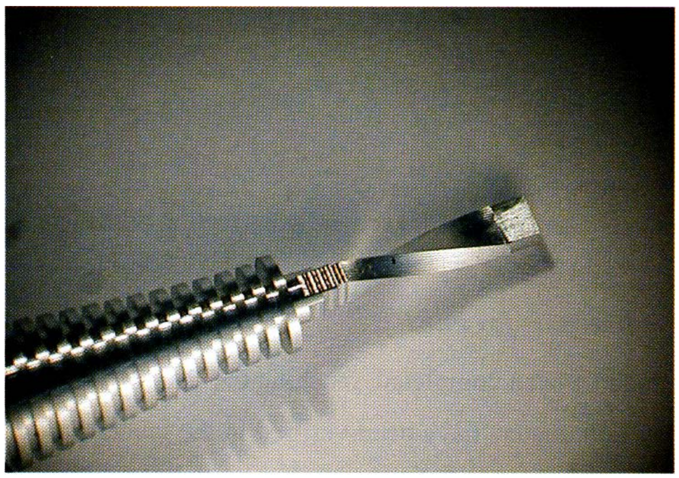

Fig. 5.6: Detail of new horn type with integrated waveguide twist and step transition. The twisted waveguide has dimensions 2.54mm x 1.27mm.

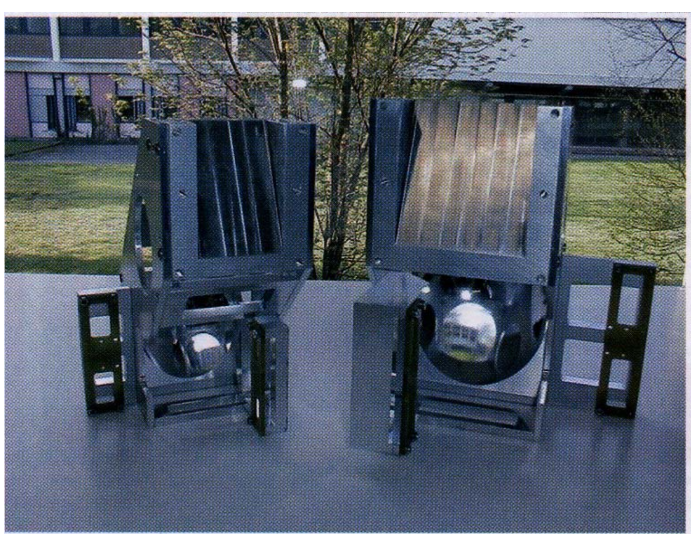

Fig. 5.7: Prototype optics modules (two elliptical mirrors each) for PdB bands 1 (83-117GHz) and 3 (200-260GHz).

Several types of electronic interfaces have been designed, prototyped, and/or series produced: junction bias, HEMT bias, vacuum monitoring. All LO boxes for band 2 (A, 2mm) have been completed except that only four of the Gunn oscillators ordered two years ago have been delivered so far. The seven frequency doublers for band 2 have been built but not yet tested. The series production of 4-8GHz HEMT amplifiers at the Yebes Observatory has been held up by the limited availability of InP devices; a development contract with the IFH at the ETH Zurich has given good results and should result in the near future in the series production of the transistors for the 56 amplifiers required for the project.

Maintenance

The dual-channel receiver of PdBI antenna 5 was replaced. The spare PdB cryostat had to be sent for repair after it developed a cold leak.

One of the 100/230 GHz dual-channel receivers at the 30m was repaired following an open in the 230 GHz junction circuit. The two spare dual-channel receivers 100/230 and 150/270, so far stored in Grenoble, were shipped to Pico Veleta to allow for prompt replacement in the case of a breakdown.

Development and misc. activities

Mixer designs for PdB band 2 (λ 2mm) and band 3 (λ 1.3mm) were completed and handed over to the SIS group. These designs are specifically aimed for SSB tuning using a moving backshort, to minimize the system noise in astronomical observations.

A prototype of a fully electronic LO chain for the band 260-375GHz has been built. It consists in a phase-locked microwave YIG oscillator, active multipliers, a mm-wave amplifier, and a fixed-tuned tripler. There are at least two motivations for this development: a) to develop an alternative solution for future IRAM receivers, given the increasing difficulties of procurement of critical components from suppliers; b) provide a LO source with no moving parts for automated tests in the laboratory, either for mixer testing or for IRAM's vector network analyzer.

Also, quarter wave plates for 86GHz VLBI using the PdBI phased array have been made, tested, and delivered, and a substantial number of components (isolators, filters, amplifiers) has been characterized. Other components (multipliers, harmonic mixers) were repaired as needed.

5.5.2 **ALMA Activities**

Sideband separating mixer for Band 7

A sideband separating module, consisting in previously developed DSB mixers and a compact combination of a power splitter and three couplers, has been built and tested. Apart from some limitations in the IF bandpass, the measured performance is consistent with the ALMA specifications.

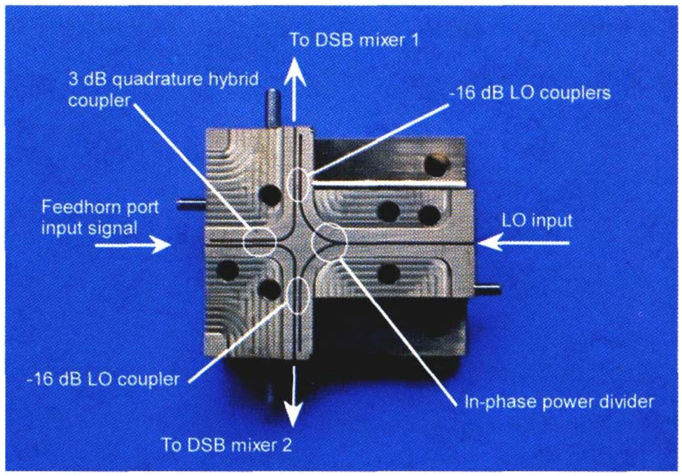

Fig. 5.8: The combination of quadrature hybrid, LO power splitter, and LO injection couplers that is the central element of the prototype sideband separating mixer for ALMA band 7.

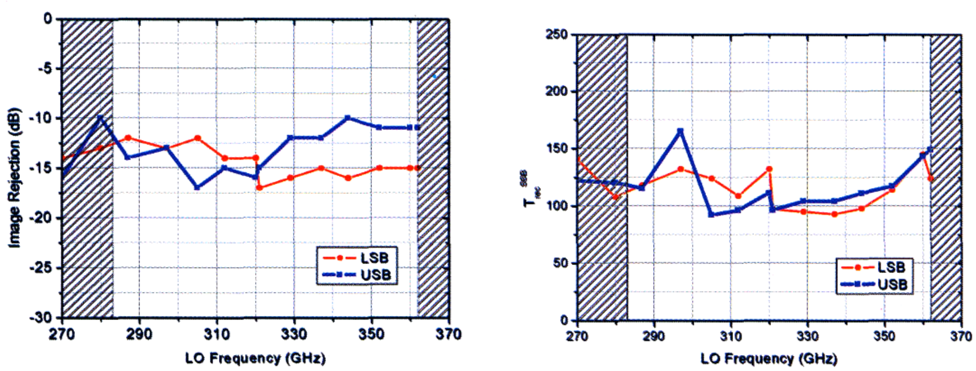

Fig. 5.9: Results obtained with the prototype sideband separating mixer for ALMA band 7. Left: image band rejection; right: (quasi-)SSB noise temperature in a narrowband IF.

Low capacitance mixer chip

In view of the IF bandpass limitations of the prototype DSB and sideband separating mixers, two new designs for band 7 mixer chips have been made, with a special effort on minimizing the parasitics (capacitance, inductance) on the IF port. These two designs represent different tradeoffs between expected performance and technological risk. The mixer chip of design 2, as a first step, is being fabricated by IRAM's SIS group.

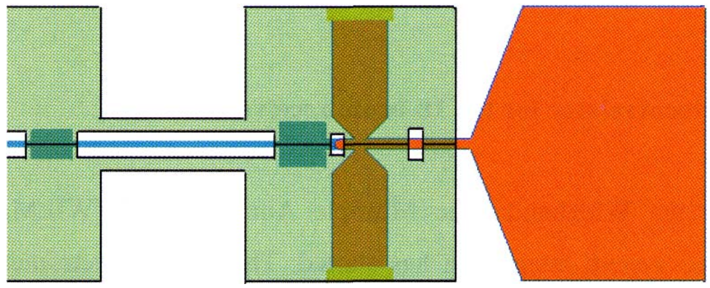

Fig.5.10: Layout of one of the low-capacitance mixer chips (detail). This design incorporates (besides the junction) striplines, coplanar lines, suspended striplines, shorted tuning stubs, with a total of three metallization layers.

Optics package

IRAM has co-ordinated the verification of the optics for ALMA bands 1, 2, 3, 4, 6, 7, and 9, and their interfaces to the cryogenics sub-system.

Prototype horns for bands 1, 2, 3, and 7 were tested for return loss and beam pattern.

The horns for the holographic adjustment of the panels on the ALMA prototype antennas have been characterized.

HDPE and quartz windows for the ALMA "evaluation" receivers have been characterized.

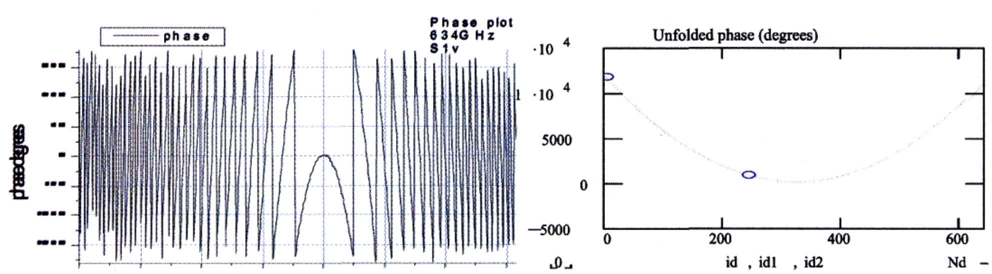

Fig.5.11: Phase pattern of a prototype feed for ALMA band 9. Left: phase modulo *2π;* right: unfolded phase, showing that coherent measurements could be made up to the edge of the pattern, where the amplitude is -30dB from boresight. The measurements have been carried out together with a SRON team from Groningen.

5.3 BACKEND DEVELOPMENTS

5.3.1 Wideband autocorrelator for the 18-beam receiver

All the modules for the Wideband Line Multiple Autocorrelator (WILMA) have been produced in series and system integration has started. The whole spectrometer (18x1 GHz, 2MHz/channel) is very compact (one rack), and has a power consumption of 2.5 kW.

Fig. 5.12: WILMA being assembled in the lab

A comparison of this machine with the current Plateau de Bure cross-correlator shows that it is superior both in terms of sampling capacity (74 Gigabits/sec versus 61) and processing power (9.4 Teramultiplications/sec versus 7.8)

This machine is made out of 18 identical slices of 1 GHz each. A supplementary slice has simultaneously been built and sent to the Yebes Observatory. Details are given on the webpage *http://www. iram.fr/IRAAfFR/TA/backend/veleta/wilma.*

5.3.2 Successful phased-array mode for VLBI on the PdB

The addition of the signals from the 6 antennas in the correlator has been tested for the first time during the October VLBI session. So were the formatter and recorder. The equipment behaved remarkably well and excellent quality fringes have been obtained with Effelsberg. Bad weather prevented Pico Veleta to join the experiment. The tied array processing scheme features digital delay compensation, digital summation within each of the 16 VLBI sub-bands, and real-time DDS control of the LO phases. Deatails are given on the webpage *http://www.iram.fr/IRAMFR/TA/backend/vlbi.*

5.3.3 ALMA

Many system problems induced by the fine delay 4 GHz sampling clock scheme have been studied at IRAM and several solutions proposed. The designs for the sampler/demux unit (U-Bordeaux group), for the signal transport (NRAO group), and for the clock itself (IRAM) have appeared to be technically interdependent. After several iterations, a solution has been validated. A specification has been issued so detailed design of the electronics can start. Details are given on the webpage *http://www.iram.fr/IRAMFR/TA/backend/samchck.*

5.4 COMPUTER GROUP

5.4.1 Hardware changes in Grenoble and Plateau de Bure

Redundant DVD servers for reading and recording DVDs and transferring data to DATs have been installed. These servers are mainly used by the astronomers for accessing archive data from the PdB interferometer.

A redundant general purpose network server has been set up. It is based on Linux. It includes all the BIND and NIS services, the mail service etc.

The back-end computers bure2/bure3 on the Plateau de Bure have been reconfigured to be interchangeable. A mirroring is executed every hour, and bureS, the spare machine, would automatically replace the master machine, bure2, in case of CPU problems. On both machines, master and spare, DVD recording facilities have been set up.

At the Plateau de Bure the cabling in 100BT has been completed with the optical fiber link between the computer room and the living quarter. The distribution to the offices will be executed by the technicians working there and all the twisted cables will end to the switch already plugged to the optical fiber.

The ISDN link between the networks in Grenoble and on the PdB has been increased to 384Kbits/s. Today this capacity is only used during video conferences between the IRAM headquarter and the observatory.

5.4.2 Software and Hardware Development Projects

For archiving on DVD's, the system tools loadDVD and buildDVD have been written and the backup and savedata utilities have been updated.

With the increasing number of PC running under Linux, a customization procedure has been written to simplify the installation of those machines with 2 options, desktop and laptop.

The configurations of all the PC have been collected automatically with the help of a product called Visual Audit pro and made available through a data base system FileMaker pro which is installed on a server. This information is supposed to improve the maintenance of our fleet.

The computer group in Grenoble has been supporting the development of the new antenna control software for the 30m in the context of the NCS project. The environment includes VME chassis, a PowerPC diskless Single Board Computer and Linux as the operating system. A first series of tests has been completed before the summer for testing the main control algorithms. The Cascade controller still has to be worked out.

On the hardware side, the computer group has manufactured and tested the second series of counter cards for the new Pico Veleta spectrometer. In addition, VME counter cards have also been produced for the 22GHz receivers that that have been/will soon be installed on the 6 PdB antennas.

5.4.3 ALMA related activities

A user interface for ALMA has been written in Python/tk and delivered. It has been used for the first prototype antenna tests on the site.

Some modules have been added to the simulation box which runs under Linux and CAN. They simulate different Front End elements.

Furthermore, a feasibility study for replacing VxWorks by a real time version of Linux has been completed by fall. This work will continue with a detailed evaluation.

For the ALMA calibration system, a table has been designed and developed. It works with a stepper motor and is interfaced to the CAN bus.

5.5 TECHNICAL GROUP

5.5.1 Extension of the mechanical workshop and new office space

During April and May of 2002, the building extension was finished which finally provides adequate space for the high-precision CNC machines that have been bought over the last few years, including as the latest addition a new CNC 4 axes lathe. The workshop staff now also has offices available which are equipped with the necessary computers in order to properly prepare the work with the CNC machines.

5.5.2 Mechanical Workshop

The staff in the workshop has dealt with a total of 147 requests for mechanical components, of which 93 were handled internally (drawings and fabrication), and 54 were subcontracted to outside companies (preparation and follow up of the dossiers).

Among the components developed and built in house are those:

- for the new generation of the Pdb receivers (NG2): 230 GHz couplers, DSB mixers, 115 GHz horns and "twisters"
- for the 22 GHz water vapour radiometers
  for the Band 7 ALMA receiver
- for the second polarisation for the multi-beam receiver, as
  well as optics components like lenses etc.

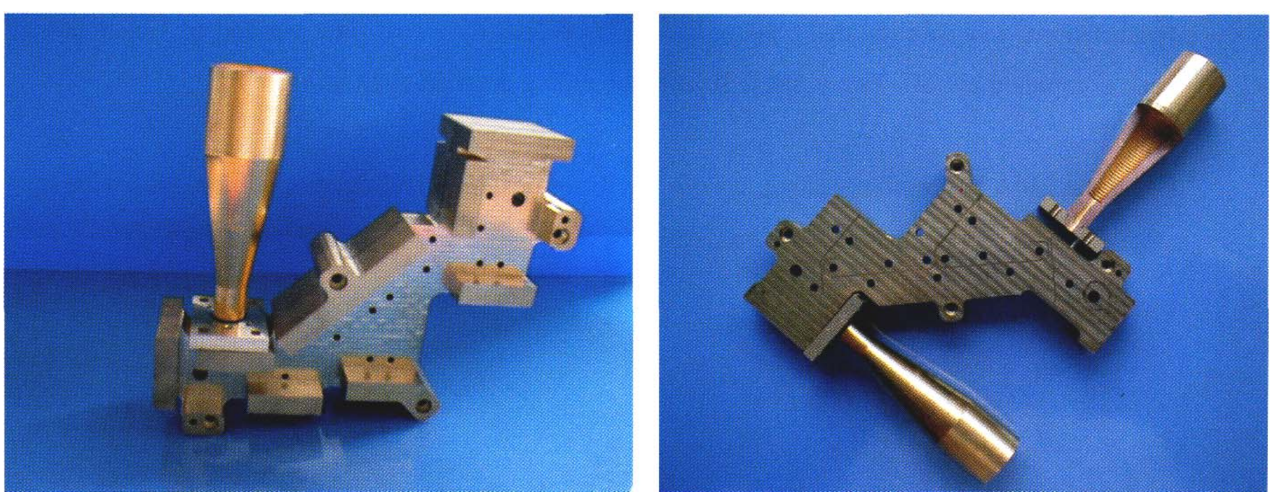

Fig. 5.13: 230 GHz couplers fabricated by the IRAM workshop staff

In addition to these machined components, 20 horns have been produced by electro-forming. These are needed for the new generation of PdB receivers as well as for the 9 additional channels for the multibeam receiver.

5.5.3 Drawing Office

The drawing office has prepared the detailed drawings for all in house development projects like the new generation of Plateau de Bure receivers (NG2), the ALMA Band 7 development work, the multibeam heterodyne array, and the 22 GHz water vapour radiometers. Support was also given to the S.I.S. group.

The drawing office staff is furthermore responsible for keeping all drawings updated, included the set of drawings for the Plateau de Bure antennas after the construction of antenna n°6.

5.5.4 Work for the Plateau de Bure Observatory

Together with the Bure technical team, the group participated in the maintenance of the antennae, and worked on the improvement of the mechanical systems.

The mechanical group also dealt with the conception and the construction of the transport accessories (plateaus, water and fuel tanks,) in collaboration with the safety engineer of IRAM and external experts and contractors.

6. PERSONNEL AND FINANCES

6.1 Personnel

The personnel plan for the year 2002 allowed for 105 positions. *De facto* only 97.2 positions were filled with staff on longer-term or unlimited contracts while as many as 13.6 positions were used for shorter-term contracts (see below). Of the staff positions, 70.8 are based in France and 26.4 in Spain. The MPI fur Extraterrestrische Physik (Garching) financed 0.25 of a position in the SIS laboratory, and the MPI fur Festkörperforschung (Stuttgart) financed 1 secretary position as of March 2002.

Furthermore, 3 post-docs (3 FR), and 3 thesis students (2 FR, 1 ES), plus 2 persons delegated by DEMIRM/Paris in the framework of the FIRST project and the ALMA project, worked at IRAM.

Extra workloads during certain periods of the year made it necessary to issue a large number of limited-term contracts. This corresponded to:

- 6.94 man-years on Bure, including Interim workers, to complete the 3 teams for maintenance and for logistical and medical support,
- 6.68 man-years in Grenoble, for replacements and additional work in the Administration and in the technical groups.

6.2 Finances

IRAM's financial situation in 2002, as well as the budget provisions for 2003, are summarised in the attached tables.

2002 - Operating budget

The total income and the actual expenses very closely matched. The total level was slightly higher than expected, both on the income side and for the expenses.

The largest variations on the income side came from provisions made in previous years, from reimbursements that IRAM received for and from higher than expected bank interests.

The savings made in the staff budget costs by not occupying all positions were more than offset by the large amount of subcontracting to manpower companies, in part because of the greater flexibility that this scheme offers and that is needed. Manpower shortages both on the Plateau de Bure and in Grenoble, necessitated a much larger than before number of short-term contracts.

Higher than anticipated costs occurred also in the running of the laboratories and the observatories, and in particular in the transport to and from the Plateau de Bure. In addition, substantial new provisions were made, especially in connection with the cable car accident from 1999.

2002 - Investment budget

a) Expenditure concerned mainly :

- continuing investment into the next generation of PdB receivers
- construction of a ALMA band 7 prototype receiver
- construction of 22 GHz radiometers for all PdB antennas for the correction of atmospheric phase fluctuations
- construction of 4-MHz filterbanks for the 30m-telescope
- construction of a wide-band autocorrelator for the 18-channel HERA receiver
- purchase of components for the IF transmission through optical fibres on the PdB
- investment into a plasma etching machine
- extension of the mechanical workshop and associated office space

b) Income

Within about 10 KEUROS the income was as predicted.

Taking into account the carry-forward from the 2000 and 2001 budgets, the 2002 investment budget was in excess by about 1 MEUROS. Of this sum, 0.7 MEUROS correspond to outstanding commitments where orders have been placed but not yet paid.

BUDGET 2002
(in EUROS)

2002 - EXPENDITURE

Budget heading	Approved	Actual
Operation / Personnel	6,718,000	6,752,854
Operation / other items	2,878,671	2,944,560
TOTAL OPERATION	9,596,671	9,697,414
Investment (general + 6th antenna)	3,410,661	2,419,274
TOTAL EXPENDITURE excl. VAT	*13,007,332*	*12,116,688*
VAT	825,653	825,653
TOTAL EXPENDITURE incl. VAT	*13,832,985*	*12,942,341*

2002 - INCOME

Budget heading	Approved	Actual
CNRS contributions	4,947,657	4,947,657
MPG contributions	4,947,657	4,947,657
IGN contributions	631,615	631,615
TOTAL CONTRIBUTIONS	*10,526,929*	*10,526,929*
Carry forward from 2000/01 (Op+Inv.)	2,074,037	2,074,037
I RAM's own income	406,366	524,707
TOTAL INCOME excl. VAT	*13,007,332*	*13,125,673*
CNRS contribution for VAT (20,6%/19,6%) *	825,653	825,653
TOTAL INCOME incl. VAT	*13,832,985*	*13,951,326*

BUDGET PROVISIONS 2003

(in EUROS)

2003 - EXPENDITURE

Budget heading	**Approved**
Operation / Personnel	6,994,000
Operation / other items	3,047,317
TOTAL OPERATION	10,041,317
Investment - general	2,642,127
TOTAL INVESTMENT	2,642,127
TOTAL EXPENDITURE	*12,683,444*
VAT (19,6%)	842,992
TOTAL EXPENDITURE incl. VAT	*13,526,436*

2003 - INCOME

Budget heading	**Approved**
CNRS contributions	5,036,120
MPG contributions	5,036,120
IGN contributions	642,908
TOTAL CONTRIBUTIONS	10,715,148
Own income	753,503
Carry forward from 2001	1,214,793
TOTAL INCOME excl. VAT	*12,683,444*
CNRS contribution for VAT (19,6)	842,992
TOTAL INCOME incl. VAT	*13,526,436*

7. ANNEX I: TELESCOPE SCHEDULES / 7.1. 30m-Telescope

JANUARY 01 - JANUARY 15

Ident.	Title	Freq (GHz)	Authors
205.01	Heavey molecular species in AGB and post-AGB stars : from acetylene to aromatics	82-92,1-2,230	Cernicharo, Pardo, Guélin, Neri
126.01	The dust-enshrouded formation of massive elliptical galaxies	Bolometer	Ivison, Dunlop, Bertoldi, Carilli, Lutz, Bales, Greve, Fox
127.01	Molecular outflows in a sample of ultracompact HII regions	98,219	Feldt, Henning, Klein, Pascucci, Schreyer, Stecklum
201.01	Spectral survey of CRL618 at mm wavelengths	160-172,242-244	Cernicharo, Pardo, Guélin, Goicoeches, Neri
191.01	Chlorine and temperature in Io's atmosphere	143,234,215,138, 104,251	Lellouch, Paubert, Moses, Schneider, Strobel
405.01	**MAMBO Observingpool Nb. 5**		

JANUARY 15 - JANUARY 29

Ident.	Title	Freq (Ghz)	Authors
191.01	Chlorine and temperature in lo's atmosphere	143,234,215,138, 104,251	Lellouch, Paubert, Moses, Schneider, Strobel
406.01	**MAMBO Observingpool Nb. 6**		
406.01	**MAMBO Observingpool Nb. 7**		

JANUARY 29 - FEBRUARY 12

Ident.	Title	Freq (Ghz)	Authors
408.01	**MAMBO Observing pool Nb. 8**		
409.01	**MAMBO Observing pool Nb. 9**		

FEBRUARY 12 - FEBRUARY 26

Ident.	Title	Freq (Ghz)	Authors
410.01	**MAMBO Observing pool Nb. 10**		
Δ22.01	Hera follow-up to "Confinement of a dense filament by helical magnetic fields 7	220	Falgarone, Hily-Blant, Pudritz, Pineau des Forêts
108.01	Outflows toward infrared dark clouds	230	Wyrowski, Carey, Egan, Feldman
194.01	1C 10 : A search for extended diffuse molecular gas	230,220,210	Muehle, Greve, Huettemeister, Schuster, Hily-Blant, Klein
099.01	A high resolution square degree field CO map in Taurus	231	Schuster

FEBRUARY 26 - MARCH 12

Ident.	Title	Freq (GHz)	Authors
099.01	A high resolution square degree field CO map in Taurus	231	Schuster
121.01	The impact of galaxy interaction on the molecular gas in NGC 3077	230,220,110	Fritz, Weiss, Walter
140.01	The evolution of outflows in young massive (proto)stars	230,219	Fontani, Brand, Cesaroni, Molinari, Testi, Walmsley, Zhang
142.01	The peculiar physical properties of the molecular gas in NGC 1569	230,110,220	Muehle, Huettemeister, Klein, Fritz
184.01	Massive molecular outflows	230	Lebron, Chiong, Beuther, Menten, Schilke, Sridharan
192.01	Jets and molecular outflows from Orion protostars	230,217,115,86	Stanke, McCaughrean, Menten, Nuernberger, Schilke, Smith, Zinnecker
128.01	Molecular gas in young planetary nebulae	115,231,113,226	Huggins, Bachiller, Cox, Forveille
101.01	Dynamical state of massive protocluster condensations in Mon OBI	86,96,140,154,216	André, Belloche, Motte, Ward-Thompson

MARCH 12 - MARCH 26

Ident.	Title	Freq. (GHz)	Authors
	Molecular gas in young planetary nebulae		Huggins, Bachiller, Cox, Forveille
	Dynamical state of massive protocluster condensations in Mon OB1		André, Belloche, Motte, Ward-Thompson
	MAMBO Observing pool Nb. 11		
	MAMBO Observing pool Nb. 12		

MARCH 26 - APRIL 09

Ident.	Title	Freq. (GHz)	Authors
	MAMBO Observing pool Nb. 13		
	MAMBO Observing pool Nb. 14		

APRIL 09-APRIL 23

Ident.	Title	Freq. (GHz)	Authors
152.01	Searching for molecular gas at the far end of the Hubble sequence	115,114,230,229	Boecker, Schinnerer, Lisenfeld
155.01	The chemical structure of B68 from 0 to 30mags of extinction : A unique interstellar laboratory	86,88,90,113,154, 218	Bergin, Lada, Alves, Huard
124.01	Multiple CO transitions and search for CI in the $z = 4.12$ QSOPSS 2322+1944	151,91	Cox, Beelen, Bertoldi, Carilli, Djorfgovski, Isaak, McMahon
Δ21.01	Helix galaxy polar ring		Schinnerer, Scoville
143.01	CO observations of ULIRGs at different phases of merging and activity	85,93,96,201,202, 97	Lara, Alberdi, Colina, Planesas
	VLBI OBSERVATIONS		

APRIL 23 - MAY 07

Ident.	Title	Freq. (GHz)	Authors
	VLBI OBSERVATIONS	93,154,231,279	
112.01	Looking for stellar birth in starless cores	108,134,240,245	Caselli, Tafalla, Lee, Walmsley, Myers
203.01	Confirmation of our tentative detection of SiNC		Guélin, Muller, Apponi, McCarthy, Thaddeus, Cernicharo
141.01	The chemistry of the hot cores of solar type protostars		Cazaux, Castets, Ceccarelli, Tielens, Maret
189.01	Dense molecular gas in galactic disks : GMCs in M31	88,89,265,267	Brouillet, Neininger, Braine, Herpin
116.01	Deuteration of methanol in the solar type protostar IRAS 16293-2422	89,96,136,223,249	Ceccarelli, Parise, Caux, Castets, Tielens, Loinard, Herbst
145.01	Connecting PAHs to small hydrocarbons	85,87,145,216,224	Teyssier, Fosse, Abergel, Pety, Habart,
131.01	Small molecular clouds in the diffuse interstellar medium	115,110,230,	Heithausen, Walter
120.01	A 2mm line survey of the starburst galaxy NGC 253	130,135,144,170	Mauersberger, Henkel, Martin-Pintado, Garcia-Burillo
186.01	A CO survey of luminous blue compact	112,113,224,225	Williams, Garland, Guzman
169.01	CO depletion and deuteration in a HD-112µm absorbing cloud	85-110,134-176,210	Caux, Pagani, Ceccarelli, Castets, Caselli

MAY 07-MAY21

Ident.	Title	Freq. (GHz)	Authors
Δ05.02	C/2002 Cl		Bockelee-Morvan
192.01	Jets and molecular outflows from Orion protostars	230,217,115,86	Stanke, McCaughrean, Menten, Nuernberger, Schilke, Zinnecker
198.01	Has the galactic center the molecular complexity of the hot cores ?	90,101,113,211, 223	Martin-Pintado, de Vicente, Rodriguez-Fernandez
189.01	Dense molecular gas in galactic disks : GMCs in M31	88,89,265,267	Brouillet, Neininger, Braine, Herpin

MAY 21-JUNE 04

Ident.	Title	Freq (GHz)	Authors
415.01	MAMBO Observing Pool No. 15		
077.02	The polarization signature of the galactic center black hole	80 to 280	Wiesemeyer, Thum, Downes
074.02	High resolution CO mapping in Taurus	231	Schuster, Ungerechts, Wiesemeyer, Gueth, Sterzik, Thum, Lefloch
Δ21.01	Helix galaxy polar ring		Schinnerer, Scoville
154.01	The polarization of methanol masers	84,95,107,156,157	Wiesemeyer, Thum, Walmsley
031.02	Recombination lines in the starburst galaxy ARP 220	84,97,132,206, 251,279	Viallefond, Goss, Zhao
Δ11.02	Dynamical state of massive protocluster condensations in Mon OB1	86,96,140,154, 216,267	André

JUNE 04-JUNE 18

Ident.	Title	Freq. (GHz)	Authors
Δ11.02	Sakurai's object		Henkel
007.02	Deuterium fractionation in the envelopes of hot cores	85,86,144,172,258	Hatchell
041.02	CO mapping of the integral sign galaxy	114,228	Matthews, Uson, Combes, Gao
042.02	A CO survey of low surface brightness spiral galaxies	115,230	Matthews, Gao, Combes, Uson
210.01	The molecular gas reservoir in nearby powerful radio galaxies	112,113,225, 227,228	Lim, Combes, Leon, Van-Trung Dinh
416.01	**MAMBO Observing Pool No 16**		
074.02	High resolution CO mapping in Taurus	231	Schuster, Ungerechts, Wiesemeyer, Gueth, Sterzik, Thum, Lefloch
004.02	Gas stripping in a cluster center : the case of NGC 4438	115,230	Braine, Sofue, Vollmer, Combes

JUNE 18-JULY 02

Ident.	Title	Freq. (GHz)	Authors
074.02	High resolution CO mapping in Taurus	231	Schuster, Ungerechts, Wiesemeyer, Gueth,
004.02	Gas stripping in a cluster center : the case of NGC4438	115,230	Braine, Sofue, Vollmer, Combes
043.02	A critical test to the case for infall in B335	93,96,144,279	Tafalla, Mardones, Bourke, Wilner, Myers
035.02	Large-scale distribution of HCN in a sample of nearby barred galaxies		Leon, Jeyakumar, Lee, Perez-Ramirez, Verdes-Montenegro
028.02	A search for interstellar methyl ethyl ether (CH3OCH2CH3)	81,89,96,151,252	Fuchs, Winnewisser, Wyrowski, Schilke, Herbst
416.01	**MAMBO Observing Pool No. 16**		

JULY 02 - JULY 16

Ident.	Title	Freq. (GHz)	Authors
038.02	Probing the PDRs associated with ultracompact HII regions	85,103,155, 208,235	Fuente, Martin-Pintado, Rodriguez-Franco, Garcia-Burillo
016.02	Heavy molecular species in AGB and post AGB stars : from acetylene to aromatic s	3 and 2mm bands	Cernicharo, Pardo, Guélin, Neri
027.02	Discriminating models of infall-asymmetry in starless contracting cores	93,144,231,279	Bourke, Myers, Tafalla, Wilner, Lee, Caselli
037.02	A 2 mm survey of the starburst galaxy NGC 253	148,149,150,170	Mauersberger, Henkel, Martin-Pintado, Garcia-Burillo
416.01	**MAMBO Observing Pool No. 16**		

JULY 16-JULY 30

Ident.	Title	Freq. (GHz)	Authors
029.02	30m observations of the NUGA sample	88,115,230	Garcia-Burillo, Combes, Eckart, Krips, Leon, Baker, Englmaier, Tacconi, Hunt, Neri
057.02	Structure of infall in the starless core L694-2	93,140,225	Myers, Lee, Tafalla, Caselli
050.02	Cluster forming gas in the Rosette molecular	93,98,220,244	Roman, Williams, Lada
037.02	A 2 mm survey of the starburst galaxy NGC 253	148,149,150,170	Mauersberger, Henkel, Martin-Pintado, Garcia-Burillo
064.02	Looking for prestellar massive cores	93,154,231,279	Crapsi, Fontani, Caselli, Cesaroni, Walmsley

JULY 30-AUGUST 13

Ident.	Title	Freq. (GHz)	Authors
Δ16.02			Martin-Pintado
Δ15.02			Trujillo
061.02	Methanol as interstellar temperature and density tracer	96,156,241	Leurini, Menten, Schilke, Wyrowski, van der Tak, Walmsley, Flower
062.02	Completion of a survey for infall around	88,93,140	Fuller, Williams, Birks
046.02	CO observations of ULIRGs at different phases of merging and activity	85,93,201,202	Lara, Alberdi, Colina, Planesas
035.02	Large-scale distribution of HCN in a sample of nearby barred galaxies		Leon, Jeyakumar, Lee, Perez-Ramirez, Verdes-Montenegro
010.02	Searching for molecular gas in a submillimeter selected sources at low redshift	96,98,105,107	Dunnes, Bales, Clements, Webb, Lilly

AUGUST 13 - AUGUST 27

Ident.	Title	Freq. (GHz)	Authors
Δ14.02			Beuther, Schilke
025.02	The origin of doubly deuterated formaldehyde in pre-stellar cores	110.140	Bacmann, Ceccarelli, Lefloch, Steinacker, Tielens, Loinard, Castets
022.02	Multiply deuterated ammonia in the ISM : from NH3 to ND3	110,154,216, 177,207	Van der Tak, Schilke, Gerin, Roueff
189.01	Dense molecular gas in galactic disks : GMCs in M31	88,89,265,267	Brouillet, Neininger, Braine, Herpin
016.02	Heavy molecular species in AGB and post AGB stars : from acetylene to aromatics	3 and 2 mm bands	Cernicharo, Pardo, Guélin, Neri
152.01	Searching for molecular gas at the far end of the Hubble sequence	115,114,230,229	Boeker, Schinnerer, Lisenfeld
071.02	A search for interstellar ethylene glycol towards star forming regions	88,130,217	Bruenken, Thorwirth, Wyrowski, Schilke, Mueller, Fuchs, Winnewisser
040.02	Where is the molecular gas in NGC 4700 ?	114,229	Dahlem, Lisenfeld, Walter
069.02	Chemistry of circumnuclear disks in AGNs : NGC 1068	86,129,130, 225,226	Usero, Garcia-Burillo, Martin-Pintado, Fuente

AUGUST 27- SEPTEMBER 10

Ident.	Title	Freq. (GHz)	Authors
069.02	Chemistry of circumnuclear disks in AGNs : NGC 1068	86,129,130, 225,226	Usero, Garcia-Burillo, Martin-Pintado, Fuente
049.02	Triggered massive star formation	97,110,220,230	Deharveng, Zavagno, Leflmoch
020.02	Physical conditions and chemistry in Barnard 1	85,110,144, 216,230,241	Gerin, Roueff, Lis, Van der Tak, Schilke
016.02	Heavy molecular species in AGB and post AGB stars : from acetylene to aromatics	3 and 2 mm bands	Cernicharo, Pardo, Guélin, Neri
051.02	A deep search for Formaldehyde and methanol towards IRC+10216	140,151,241	Schilke, Ford, Neufeld, Melnick
030.02	A search for interstellar methyl ethyl ether (CH2OCH2CH3)	81,89,96,151,252	Fuchs, Winnewisser, Wyrowski, Schilke, Herbst
155.01	The chemical structure of B68 from 0 to 30 mags of extinction : A unique interstellar laboratory	86,88,90,113, 154,218	Bergin, Lada, Alves, Huard

SEPTEMBER 10 - SEPTEMBER 24

Ident.	Title	Freq. (GHz)	Authors
016.02	Heavy molecular species in AGB and post AGB stars : from acetylene to aromatics	3 and 2 mm bands	Cernicharo, Pardo, Guélin, Neri
030.02	A search for interstellar methyl ethyl ether (CH2OCH2CH3)	81,89,96,151,252	Fuchs, Winnewisser, Wyrowski, Schilke, Herbst
Δ17.02			Henning
Δ12.02			Castets
073.02	Methanol deuteration in solar type protostars	91,134,226,271	Parise, Ceccarelli, Caux, Maret, Castets, Tielens, Loinard
075.02	Search for CO in SMM, J00266+1708 - continued	101 to 96, 115	Downes, Solomon, Evans

SEPTEMBER 24 - OCTOBER 8

Ident.	Title	Freq. (GHz)	Authors
Δ18.02			Lapinov
501.02	**MAMBO Observing Pool No. 1**		
53.02	H2S and SO2 as a probe of the evolution of molecular outflows	114,241,168, 216,98	Codella, Bachiller, Benedettini, Caselli

OCTOBER 8 - OCTOBER 22

Ident.	Title	Freq. (GHz)	Authors
502.02	**MAMBO Observing Pool No. 2**		
503.02	**MAMBO Observing Pool No. 3**		

OCTOBER 22 - NOVEMBER 5

Ident.	Title	Freq. (GHz)	Authors
504.02	**MAMBO Observing Pool No. 4**		
	VLBI Observing Run		

NOVEMBER 5 - NOVEMBER 19

Ident.	Title	Freq. (GHz)	Authors
057.02	Structure of infall in the starless core L694-2	93,140,225	Myers, Lee, Tafalla, Caselli
101.02	Large-scale distribution of HCN in a sample of nearby barred galaxies	112,113,225,228	Lim, Combes, Van-Trung, Leon
505.02	**MAMBO Observing Pool No. 5**		
Δ20.02			Parise, Ceccarelli
185.02	2002 Leonids : HCN delivery and O3 destruction	HERA	Despois, Biver, Koschny, Zender, Lautie, Ricaud, Schneider, Urban, Jenniskens

NOVEMBER 19 - DECEMBER 3

Ident.	Title	Freq. (GHz)	Authors
148.02	Search for interstellar CD3OH and CD3OD	110,156,221,273	Van der Tak, Schilke, Mueller, Thorwirth
178.02	SiO maser emission monitoring in the protoplanetary nebula OH23 1 .8+4.2	86,214,215	Sanchez-Contreras, Bujarrabal, Alcolea, Soria, Desmurs, Colomer
164.02	The high density nucleus of evolved prestellar cores	93,154,231,279	Crapsi, Caselli, Bourke, Won-Lee, Tafalla, Myers, Walmsley
106.02	The galactic circumnuclear ring deuterium abundance	86,144,217, 239,265	Henkel, Lubowich, Mauersberger, Millar, Roberts, Psaschoff, Kuno
185.02	2002 Leonids : HCN delivery and 03 destruction	HERA	Despois, Biver, Koschny, Zender, Lautie, Ricaud, Schneider, Urban, Jenniskens
147.02	A CO line survey of an unbiased sample of hyperluminous infrared galaxies	110	Verma, Baker, Rigopoulou, Serjeant, Farrah, Efstahiou, Rowan-Robinson
125.02	The impact of galaxy interaction on the molecular gas in NGC 3077	HERA	Fritz, Weiss, Calter
161.02	Understanding molecular depletion in low mass cores	HERA	Tafalla, Caselli, Myers, Walmsley, Crapsi

DECEMBER 3 - DECEMBER 17

Ident.	Title	Freq. (GHz)	Authors
201.02	**MAMBO Observing Pool No. 1**		
202.02	**MAMBO Observing Pool No. 2**		

DECEMBER 17 - DECEMBER 31

Ident.	Title	Freq. (GHz)	Authors
116.02	Searching for evidence of triggered massive star formation	HERA	Zavagno, Deharveng, Lefloch, Brand, Massi
174.02	Very diverse environments within the post-starburst galaxy NGC 1569	HERA	Muehle, Klein, Huettemeister, Fritz
203.02	MAMBO Observing Pool No. 3		
111.02	Complex molecules as tracers of starburst evolution in the ULIRG Arp 220	87,100,154, 218,227,263	Mauersberger, Huettemeister, Aalto-Bergman, Bergman
133.02	The 2mm line survey of the starburst galaxy NGC 253. The last step	150,250,235,260, 88-137	Martin, Mauersberger, Henkel, Martin-Pintado, Garcia-Burillo
178.02	SiO maser emission monitoring in the protoplanetary nebula OH23 1.8+4.2	86,214,215	Sanchez-Contreras, Bujarrabal, Alcolea, Soria, Desmurs, Colomer

7. ANNEX I: TELESCOPE SCHEDULES/ 7.2. PdB Interferometer

Iden t.	Title	Line	Authors
L024	CO and dust emission in the z = 4.12 QSO PSS2322+1944	$^{12}CO(4\text{-}3)$ $^{12}CO(10\text{-}9)$	P.Cox A.Beelen F.Bertoldi C.Carilli J.D.Djorgovski K.Isaak R.McMahon
L029	Molecular gas in the innermost 1 kpc of the nearby QSO HE 1136-2304	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	M.Krips A.Eckart J.Staguhn S.Leon T.Bertram C.Straubmeier
L02B	Molecular gas in the nearby QSO host of HE1029-1831	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	A.Eckart M.Krips J.Staguhn S.Leon T.Bertram C.Straubmeier
L02D	The Keplerian disk around the high-mass protostar IRAS20126+4104	$C^{34}(2\text{-}l)$ $C^{34}(5\text{-}4)$	R.Cesaroni R.Neri L.Olmi L.Testi P.Hofner
L02E	CO search in High Redshift PSS Quasar - continued	$^{12}CO(4\text{-}3)$ Cont1mm	P.Cox A.Omont F.Bertoldi A.Beelen, J.D.Djorgovski
L030	The CO shell of Betelgeuse	$^{12}CO(1\text{-}0)$ $^{2}CO(2\text{-}1)$	K.Isaak R.McMahon T.Forv eille P .Huggins R.Bachiller P.Cox
L031	Chemistry in Disks around Herbig Ae Stars	HCN HCC HCO+ HNC N_2H+ CS CN	T.Henning A.Bacmann M.Ilgner R. Klein K.Schreyer
L032	Molecular clouds in M31 at the parsec scale: structure and mass determination in forbidden regions	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	N.Neininger S.Muller M.Guélin R.Lucas R.Wielebinski H.Ungerechts
L036	High-resolution CO observations of yellow hyper giants	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	A.Castro-Carrizo V.Bujarrabal J.Alcolea R.Neri R.Lucas
L037	Unveiling the Structure in High Redshift Submm Galaxies	$^{12}CO(3\text{-}2)$ ^{12} CO (7-6) Cont 1mm	R.Genzel L.Tacconi A. Baker
L038	Extragalactic chemistry of starbursts: NGC 253	SO(3-2) $CH_3OH(5\text{-}4)$	S.Garcia-Burillo A.Fuente J.Martin-Pintado
L03A	Circumstellar material around early-type HAEBE stars	$^{13}CO(1\text{-}0)$ $^{13}CO(2\text{-}1)$	A.Fuente J.Martin- Pint ado R.Bachiller A.Natta L.Testi A.Rodriguez-Franco
L03B	The central gas flow in double-barred galaxies: NGC 3368	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	E.Schinnerer W.Maciejewski A. Baker
L03C	Massive star formation within contracting protoclusters in W43	CS(2-1) $C^{34}S(5\text{-}4)$	P .Schilke F.Motte D.Lis
L03D	Are PAHs precursors of small hydrocarbons ? The Horsehead case	CsH2 C4H $C^{18}O(2\text{-}1)$	J.Pety D.Fossé D.Teyssier M.Gerin A.Abergel E.Habart
L040	A massive proto-cluster in its making: X-ray to mm-observations	CS(2-1) CS(5-4)	H.Beuther P.Schilke K.Menten J.Kerp
L041	CO emission from dusty radio galaxies at very high redshifts	$^{12}CO(4\text{-}3)$ Contlmm	C.DeBreuck A.Omont B.Rocca-Volmerange R.Neri M.Reuland W.vanBreugel W.deVries H.Röttgering
L042	Late-Stage Galaxy Mergers and the Fundamertal Plane	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	L.Tacconi R.Genzel A. Baker M.Tecza C.Iserlohe
L044	Rotation in a circumbinary dust ring around TMR-1 ?	$^{13}CO(1\text{-}0)$ $^{13}CO(2\text{-}1)$	M.Petr-Gotzens P.Schilke A.Walsh

Ident.	Title	Line	Authors
L047	Nuclei of Galaxies: gas dynamics and AGN fuelling	$^{12}CO(1-0)$ $^{12}CO(2-1)$	S.Garcia-Burillo F. Combes A.Eckart L.Tacconi L.Hunt S.Lebn A. Baker P.Englmaier F.Boone E.Schinnerer R.Neri
L049	Higher-resolution maps of two PPNe: IRAS 1743 and IRAS 1950	$^{12}CO(1-0)$ $^{12}CO(2-1)$	J.Alcolea A.Castro-Carrizo V.Bujarrabal R.Neri
L04A	Molecular gas in distant, ultraluminous submillimetre-selected galaxies	$^{12}CO(3-2)$ $^{12}CO(7-6)$	D.Downes P.Solomon R.Ivison I.Smail A.Blain
L04E	The most luminous source in the Orion KL hot core	$^{12}CO(1-0)$ $HC_3CN(23-22)$	P .deViceite J.Martin-Pintado R.Neri
L050	Imaging the Molecular Gas Disk in the FR I Radio Galaxy 3C31	$^{12}CO(1-0)$ $^{12}CO(2-1)$	J.Lim F. Combes S.Leon van-Trung Dinh
L058	Probing the structure of the high-redshifted lensed AGN MG0751+2716	$^{12}CO(3-2)$ $^{12}CO(8-7)$	J.Kneib D.Alloin M.Bremer C.Faure
L059	Photochemistry at the DM Tau disk surface	HCN(1-0) DCO+(3-2)	V.Pietu A.Dutrey S.Guilloteau E.Dartois
L05B	V ertical structure of Protoplanetary disks orbiting PMS stars of mass < 2.5 M_0	$^{13}CO(1-0)$ $^{13}CO(2-1)$	V.Pietu A.Dutrey S.Guilloteau E.Dartois
L05C	Mapping the molecular gas and the dust of the HD 141569 circumstellar disk	HCO+ $^{12}CO(2-1)$	J.-C.Augereau A.Dutrey A.-M.Lagrance T.Forv eille D.Mouillet
L--4	The circumstellar disk of the embedded source HH30	$^{13}CO(1-0)$ $^{13}CO(2-1)$	F.Gueth A.Dutrey S.Guilloteau
L--5	Late-Stage Galaxy Mergers and the Fundamental Plane	$^{12}CO(1-0)$ $^{12}CO(2-1)$	A.Baker L.Tacconi R.Genzel M.Tecza C.Iserlohe
L--6	Monitoring of gamma-ray burst GRB 020322	Cont3mm Contlmm	M.Bremer A.Castro-Tirado
L--7	X-ray absorbed QSO/ULIRGs: implications for coeval galaxy and QSO evolution	$^{12}CO(2-1)$ $^{12}CO(3-2)$	R.J.Ivison M.Page J.Stevens
M002*	Chemistry of the DM Tau disk	C_2H H_2CO	V.Pietu A.Dutrey
M004	Searc h for molecular gas in gamma-ray burst host galaxies	$^{12}CO(2-1)$ $^{12}CO(4-3)$	S.Guilloteau E.LeFloc'h F. Combes J.Kneib J.Greiner D.Sanders I.Rodrigues G.Bosh
M005	Weighing Very Low-Mass Young Stars (0.3 - 0.6M_0)	$^{12}CO(1-0)$ $^{12}CO(2-1)$	A.Dutrey M.Simon S.Guilloteau F.Gueth R. White I.Baraffe
M007	Measuring the dynamical mass" of cB58	$^{12}CO(3-2)$ $^{12}CO(7-6)$	A.Baker L.Tacconi R.Genzel M.Lehnert D.Lutz
M008	Search for CO emission in the z = 2.57 QSO J 1408+5625	$^{12}CO(3-2)$ Contlmm	A.Beelen F.Bertoldi C.Carilli P .Coc A.Omont J.Pety P.Petitjean
M009	Search for CO in the X-ray absorbed AGN RX J094144.51+385434.8 at z = 1.819	$^{12}CO(2-1)$ $^{12}CO(6-5)$	A.Omont N.Mohan J.Bergeron P .Coc A.Beelen
M00A	Dust and CO in and around the massive forming galaxy 4C 41. 17 at £ = 3. 8	$^{12}CO(4-3)$ Contlmm	C.deBreuck A.Omont R.Neri D.Downes M.Reuland W.vanBreugel H.Röttgering
M00B	Probing the nucleosynthesis in the young Universe (II)	HCO+ $H^{13}CO$+ DCO+ HCN $H^{13}CN$ HNC $HN^{13}C$	S.Muller M.Dumke M.Guélin R.Lucas F. Combes M.Gerin T.Wiklind
M00C	Discovery of a huge SiO chimney in the halo of M82	SiO $H^{13}CO$+	S.Garcia-Burillo A.Usero J.Martin-Pintado A.Fuente R.Neri
M00D*	mm- wave absorption towards NGC 1052	HCO+ $^{12}CO(1-0)$ HCN $^{12}CO(2-1)$	H.Liszt R.Lucas

Ident.	Title	Line	Authors
M00E	Kinematics and distribution of the molecular gas in Stephan's Quintet	$^{12}CO(1-0)$ $^{12}CO(2-1)$	U.Lisenfeld S.Leon J.Braine P .Due V.Charmandaris E.Brinks
M00F	Structure in the Epsilon Eridani Debris Disk	$^{12}CO(2-1)$	D.Wilner M.Holman M.Kuchner
M010	Disentangling the phases of the ISM via Low-Latitude Molecular Absorption Profiles	HCO+ $^{12}CO(2-1)$	H.Liszt R.Lucas
M013	Chemistry in Disks around Herbig Ae Stars	HCO+ CS HCN HNC CN(6-7) HCC	T.Henning A.Bacmann M.Ilgner I.Pascucci K.Schrey er
M015*	Massive young stars, protostars, and outflows in Onsalal	SiO $H^{13}CO+$ $^{12}CO(2-1)$	R.Bachiller M.Kumar M.Tafalla
M017	The formation of a dense cirrus core	HC_3N	A.Heithausen C.Bottner
M018	Mapping cold molecular gas in cooling flows	$^{12}CO(1-0)$	P .Salome F. Combes
M019	Detecting first signs of a protostar	NH_2D $^{12}CO(2-1)$	A.Crapsi P.Caselli M.Walmsley M.Tafalla
M01B*	Molecular Gas in the 3C48 QSO Merger Host Galaxy	$^{12}CO(1-0)$ $^{12}CO(3-2)$	A.Eckart D.Downes R.Neri M.Krips J.Zuther J.Scharwachter
M01E	Fragmeitation and Dynamical Interactions in the NGC2068 Protocluster	N_2H+ DCO+	P.Andre A.Belloche F.Motte S.Bontemps
M01F	The Dynamical Mass of the High Redshift Submm Galaxy SMM 02399-0136	$^{12}CO(3-2)$ $^{12}CO(7-6)$	R.Genzel L.Tacconi A. Baker A.Omont P.Cox S.Guilloteau
M021	Detection of CO(4-3) in a z = 3.1 proto-cluster	$^{12}CO(4-3)$	S. Chapman D. Prayer
M--1	A High-resolution map of an interarm cloud in M31	$^{12}CO(1-0)$	S.Muller M.Guélin R.Lucas R.Wielebinski
M--2*	Extending Onsala 1 to the South	SiO(2-l) $^{12}CO(2-1)$	R.Bachiller M.S.N.Kumar M.Tafalla
M--3	PdBI observation of the Flying Saucer edge-on circumstellar disk	HCO+ $^{12}CO(2-1)$	N.Grosso A.Dutrey T.Montmerle J.Alves
M--4	PdB observations of GRB020531	Cont3mm	A.Castro-Tirado M.Bremer
M--5	Episodic mass loss on the AGB: an old, detached CO shell around S Set	$^{12}CO(1-0)$	H.Olofsson R.Lucas P .Bergman J.Bieging K.Eriksson B.Gustafsson
M--6	Search of [CI] in the z=4.12 QSO PSS 2322+1944 $_x$	[CI]	P.Cox A.Beelen J.Pety D.Downes F.Bertoldi A.Omont S.G.Djorgovski C.Carilli
M--7	Observations of a distant SCUBA sources with Keck redshifts	$^{12}CO(3-2)$ Cont1mm	R.Ivison R.Genzel S. Chapman A.Blain I.Smail T.Greve A.Omont F.Bertoldi P.Cox R.Neri
M--8	How to get a redshift with 4 decimal places without a redshift machine	$^{12}CO(3-2)$	D.Downes
M--9	Search for 500 AU structures in the $^{12}CO(1-0)$ emission of non-starforming clouds	$^{12}CO(1-0)$	E.Falgarone J.Pety
M-11	Spectral Index of three mm background sources	Cont3mm Contlmm	F.Bertoldi C.Carilli F.Owen K.Menten
M-12	Monitoring the bright gamma-ray burst GRB 020813	Cont3mm	M.Bremer A.Castro-Tirado
M-13	Monitoring the bright gamma-ray burst GRB 021004	Cont3mm	A.Castro-Tirado M.Bremer
M022*	The Formation of Cometary Globules in Planetary Nebulae	$^{12}CO(1-0)$ $^{12}CO(2-1)$	R.Bachiller P.Huggins P.Cox T.Forveille E.Josselin

Ident.	Title	Line	Authors
M03E*	Are PAHs precursors of small hydrocarbons? The Horsehead case	C_2H ^{13}CO $^{12}C^{18}O$	J.Pety A.Abergel M.Gerin E.Habart E.Roueff D.Teyssier
M04D*	500 AU structures in the ^{12}CO and continuum emission of a high latitude cloud	$^{12}CO(1-0)$	E.Falgarone F.Levrier J.Pety
M062*	The lensed quasar Q0957+561: Is the ^{12}CO line profile real?	$^{12}CO(2-1)$	M.Krips R.Neri A.Eckart P .Planesas L.Colina J.Martin-Pintado
M064*	CO "microflows" : a direct probe of wide-angle winds in young stars ?	^{13}CO $C^{18}O$ $^{12}CO(2-1)$	N.Pesenti C.Dougados S.Cabrit

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